TENNESSEE DEPARTMENT
OF
ENVIRONMENT AND CONSERVATION

DOE OVERSIGHT DIVISION

# ENVIRONMENTAL MONITORING REPORT

JANUARY THROUGH DECEMBER 2003

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## LIST OF COMMON ACRONYMS AND ABREVIATIONS

| | |
|---|---|
| ASER | Annual Site Environmental Report (written by DOE) |
| ASTM | American Society for Testing and Materials |
| BCK | Bear Creek Kilometer (station location) |
| BFK | Brushy Fork Creek Kilometer (station location) |
| BJC | Bechtel Jacobs Company |
| BMAP | Biological Monitoring and Abatement Program |
| BNFL | British Nuclear Fuels Limited |
| BOD | Biological Oxygen Demand |
| BWXT | Y-12 Prime Contractor (current) |
| CAA | Clean Air Act |
| CAAA | Clean Air Act Amendments |
| CAP | Citizens Advisory Panel (of LOC) |
| CCR | Consumer Confidence Report |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CFR | Code of Federal Regulations |
| COC | Contaminants of Concern |
| COD | Chemical Oxygen Demand |
| CPM (cpm) | Counts per Minute |
| CRM | Clinch River Mile |
| CROET | Community Reuse Organization of East Tennessee |
| CWA | Clean Water Act |
| CYRTF | Coal Yard Runoff Treatment Facility (at ORNL) |
| D&D | Decontamination and Decommissioning |
| DOE | Department of Energy |
| DOE-O | Department of Energy-Oversight Division (TDEC) |
| DWS | Division of Water Supply (TDEC) |
| E. coli | Escherichia coli |
| EAC | Environmental Assistance Center (TDEC) |
| ED1, ED2, ED3 | Economic Development Parcel 1, Parcel 2, and Parcel 3 |
| EFPC | East Fork Poplar Creek |
| EMC | Environmental Monitoring and Compliance (DOE-O Program) |
| EMWMF | Environmental Management Waste Management Facility |
| EPA | Environmental Protection Agency |
| EPT | Ephemeroptera, Plecoptera, Trichoptera (May flies, Stone flies, Caddis flies) |
| ERAMS | Environmental Radiation Ambient Monitoring System |
| ET&I | Equipment Test and Inspection |
| ETTP | East Tennessee Technology Park |
| FDA | U.S. Food and Drug Administration |
| FFA | Federal Facility Agreement |
| FRMAC | Federal Radiation Monitoring and Assessment Center |
| g | Gram |
| GHK | Gum Hollow Branch Kilometer (station location) |
| GIS | Geographic Information Systems |
| GPS | Global Positioning System |
| GW | Ground Water |
| GWQC | Ground Water Quality Criteria |
| HAP | Hazardous Air Pollutant |
| HCK | Hinds Creek Kilometer (station location) |
| IBI | Index of Biotic Integrity |
| IC | In Compliance |
| “ISCO” Sampler | Automatic Water Sampler |
| IWQP | Integrated Water Quality Program |
| K-#### | Facility at K-25 (ETTP) |

## LIST OF COMMON ACRONYMS AND ABREVIATIONS CONTINUED

| | |
|---|---|
| K-25 | Oak Ridge Gaseous Diffusion Plant (now called ETTP) |
| KBL | Knoxville Branch Laboratory |
| KEAC | Knoxville Environmental Assistance Center |
| l | Liter |
| $LC_{50}$ | Lethal Concentration at which 50 % of Test Organisms Die |
| LMES | Lockheed Martin Energy Systems (past DOE Contractor) |
| LOC | Local Oversight Committee |
| LWBR | Lower Watts Bar Reservoir |
| MARSSIM | Multi-agency Radiation Survey and Site Investigation Manual |
| MBK | Mill Branch Kilometer (station location) |
| MCL | Maximum Contaminant Level (for drinking water) |
| MDC | Minimum Detectable Concentration |
| MEK | Melton Branch Kilometer (station location) |
| µg | Microgram |
| mg | Milligram |
| MIK | Mitchell Branch Kilometer (station location) |
| ml | Milliliter |
| MMES | Martin Marietta Energy Systems (past DOE Contractor) |
| µmho | Micro mho (mho=1/ohm) |
| MOU | Memorandum of Understanding |
| mR | MilliRoentgen |
| mrem | 1/1000 of a rem – millirem |
| N, S, E, W | North, South, East, West |
| NAAQS | National Ambient Air Quality Standards |
| NAREL | National Air and Radiation Environmental Laboratory |
| NAT | No Acute Toxicity |
| NEPA | National Environmental Policy Act |
| NIC | Not In Compliance |
| NOAEC | No Observable Adverse Effect Concentration (to Tested Organisms) |
| NOV | Notice of Violation |
| NPDES | National Pollution Discharge Elimination System |
| NRWTF | Non-Radiological Waste Treatment Facility (at ORNL) |
| NT | Northern Tributary of Bear Creek in Bear Creek Valley |
| OMI | Operations Management International (runs utilities at ETTP under CROET) |
| OREIS | Oak Ridge Environmental Information System http://www-oreis.bechteljacobs.org/oreis/help/oreishome.html |
| ORISE | Oak Ridge Institute for Science and Education |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| OSHA | Occupational Safety and Health Association |
| OSL | Optically Stimulated Luminescent (Dosimeter) |
| OU | Operable Unit |
| PACE | Paper, Allied-Industrial, Chemical, and Energy Workers Union |
| PAM | Perimeter Air Monitor |
| PCB | Polychlorinated Biphenol |
| pCi | $1x10^{-12}$ Curie (Picocurie) |
| PCM | Poplar Creek Mile (station location) |
| pH | Proportion of Hydrogen Ions (acid vs. base) |
| PWSID | Potable Water Identification “number” |
| ppb | Parts per Billion |

## LIST OF COMMON ACRONYMS AND ABREVIATIONS CONTINUED

| | |
|---|---|
| ppm | Parts per Million |
| ppt | Parts per Trillion |
| PRG | Preliminary Remediation Goals |
| QA | Quality Assurance |
| QC | Quality Control |
| R | Roentgen |
| RBP | Rapid Bioassessment Program |
| RCRA | Resource Conservation and Recovery Act |
| REM (rem) | Roentgen Equivalent Man (unit) |
| RER | Remediation Effectiveness Report |
| ROD | Record of Decision |
| RSE | Remedial Site Evaluation |
| SLF | Sanitary Landfill |
| SNS | Spallation Neutron Source |
| SOP | Standard Operating Procedure |
| SPOT | Sample Planning and Oversight Team (TDEC) |
| SS | Surface Spring |
| STP | Sewage Treatment Plant |
| SW | Surface Water |
| TDEC | Tennessee Department of Environment and Conservation |
| TDS | Total Dissolved Solids |
| TIE | Toxicity Identification Evaluation |
| TLD | Thermoluminescent Dosimeter |
| TOA | Tennessee Oversight Agreement |
| TRE | Toxicity Reduction Evaluation |
| TRM | Tennessee River Mile |
| TRU | Transuranic |
| TSCA | Toxic Substance Control Act |
| TSCAI | Toxic Substance Control Act Incinerator |
| TSS | Total Suspended Solids |
| TTHM’s | Total Trihalomethanes |
| TVA | Tennessee Valley Authority |
| TWQC | Tennessee Water Quality Criteria |
| TWRA | Tennessee Wildlife Resources Agency |
| U.S. | United States |
| UT-Battelle | University of Tennessee-Battelle (ORNL Prime Contractor) |
| VOAs | Volatile Organic Analytes |
| VOC | Volatile Organic Compound |
| WCK | White Oak Creek Kilometer (station location) |
| WM | Waste Management |
| WOL | White Oak Lake |
| X-#### | Facility at X-10 (ORNL) |
| X-10 | Oak Ridge National Laboratory |
| Y-#### | Facility at Y-12 |
| Y-12 | Y-12 Plant (Area Office) |

## Executive Summary

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) is providing a report of its independent environmental monitoring for the calendar year 2003. The report is a series of individual reports completed by division personnel. General areas of interest organize the reports: Air Quality, Biological/Fish and Wildlife, Drinking Water, Groundwater, Radiation, Surface Water, and Sediment. An abstract is provided in each report. All supporting information and data used in the completion of these reports are available for review in the division's files.

## Air Quality Monitoring

State monitoring verified that the public was not adversely impacted from airborne releases of radionuclides. However, the state did detect increases in airborne radioactive pollutants around the DOE facilities, likely from normal operations (Y-12), and from decontamination and decommissioning operations (ETTP). Airborne contaminants directly attributable to the TSCA Incinerator at ETTP were not detected.

*Environmental Radiation Ambient Monitoring System - (ERAMS)* This EPA sponsored program detected elevated radionuclides in air at Y-12. The perimeter program also measured increased airborne radionuclides around the Y-12 plant. These releases are presumably from production and waste management operations. Y-12 has restarted production operations and also is aggressively demolishing unneeded buildings. The fugitive radiological air emission results at the ETTP Three Buildings Project were higher than background measurements for a period of time, an occurrence that also happened in 2002. Air sampling for radionuclides at ORNL mirrored results of background stations. All radiological air-sampling measurements were below Clean Air Act standards.

The Hazardous Air Pollutants - (HAPs) for metal monitoring at Y-12, ETTP, and Oak Ridge National Laboratory (ORNL) indicated no apparent elevated concentration of metals of concern. HAPs metals monitored were arsenic, beryllium, cadmium, total chromium, lead, nickel and uranium metal. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

## Biological/Fish and Wildlife

Contaminants in Fish Tissue - During 2003, the division did largemouth bass (Micropterus salmoides) fish tissue analysis to further substantiate collections and data used to determine local fishing advisories. Since this species is a popular sport fish and past evaluations have not adequately included it, the division analyzed bass through a cooperative effort with the Tennessee Valley Authority (TVA). Largemouth bass were acquired from TVA at four locations around the ORR during their annual Community Assessment Project in order to compare results with action criteria. Tissue samples from these fish were then analyzed for contaminants of concern. Results indicate that there are no contaminants present in the largemouth bass tissue that pose a threat to human health. The current local fishing advisories do not list largemouth bass and this work confirms current policy.

*Canada Geese* - On June 24 and 25, 2003, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured at this year showed elevated gamma counts above the 5pCi/g game release level. Since no contaminated geese were captured, the DOE Oversight Division did not conduct additional offsite sampling of Canada Geese.

*Aquatic Macroinvertibrates* - Semi-quantitative benthic macroinvertebrate samples were collected from study sites on five streams impacted by Department of Energy (DOE) operations. Using the state of Tennessee standard operating procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using applicable metrics. A score was calculated from the metrics and a stream site health rating was assigned. In general, results showed signs of biotic improvement with increasing water quality downstream of DOE influences. Only two study sites had a stream rating as healthy as bioregion reference conditions. Continued benthic macroinvertebrate monitoring would more closely define impacts on the aquatic environment from DOE related activities. Assessments of DOE remedial activities and cleanup efforts can also be made from these data.

*Deer hunts* were held on the ORR in 2003. Deer hunts resulted in 256 animals killed with two retained because of internal contamination (0.8%). Hunters reported these two animals to be from areas proximate to known contamination areas at ORNL. Since the annual hunts began in 1985, 8519 deer have been killed with 170 retained (2.0%). The Oak Ridge National Laboratory supports the state by testing tissue samples at the check stations while hunters wait. This screening prevents public consumption of contaminated meat from game animals killed on the ORR. Contamination in wildlife is also an indicator of the effectiveness of remedial efforts on contaminated streams, springs, and burial areas. The state did no independent sampling of deer in 2003. Turkey hunts in the spring of 2003 were suspended for security reasons. The DOE work is mentioned in this summary due to its importance.

*Invasive plant mapping* of a Black Oak Ridge Conservation Easement was started to get a handle on the ecological health and possible future management needs. Since this was an unplanned project for 2003 (not included in the 2003 Environmental Monitoring Plan) and much of the fieldwork is yet incomplete (only about 40% finished), results will be covered in more detail in the 2004 Environmental Monitoring Report. Resumption of field-mapping activities will commence in the spring of 2004. From this initial mapping effort, we observed that the majority of the exotic species occur along existing gravel roads, pine-beetle damaged pine plantations, and formerly disturbed sites. Here, the exotics have little competition for habitat space. However, in the case of Kudzu infestations it does not seem to matter about competition from native plants as this aggressive invader takes over all vegetation (living or dead), open space, etc. There are, however, infested locations in the backcountry away from roads or trails.

## Drinking Water

*Chlorine Residuals* The monitoring activities through oversight and independent sampling of the sanitary water distribution systems on the ORR met the regulatory requirement of 0.2 mg/L for residual chlorine. No elevated levels of bacteria above the regulatory limits were reported. The Environmental Radiation Ambient Monitoring System (ERAMS), which samples from five local drinking water treatment plants, indicate that radionuclides are well below regulatory criteria. However, tritium has historically been found in higher concentrations for the Gallaher water treatment plant than the four other systems monitored in the program. The plant is located about seven river miles downstream of White Oak Creek which drains the ORNL watersheds.

*ORNL drinking water* was sampled for radionuclides in facilities serviced by lines running through and near the highly contaminated Core Hole 8 plume at ORNL. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of Core Hole 8. Results of the sampling indicate that, at the time of sampling, there were no radiological contaminants in the drinking water system in the vicinity of core hole 8.

## Groundwater

*Springs and Residential Wells* - The calendar year 2003 groundwater-sampling projects included six (6) separate residential sources and seventeen (17) exit pathway springs. Residential water sources were monitored for the presence of DOE related nuclear waste. Exit pathway springs in the peripheral areas of the Oak Ridge Reservation were monitored for determination of quality and effectiveness of DOE’s monitoring and surveillance programs. Also, one (1) monitoring well was co-sampled as an independent oversight activity. Residential wells showed no evidence of contamination. Spring sampling showed that contamination exists beyond mapped plume boundaries.

## Radiation

*Ambient Radiation* - The Tennessee Department of Environment and Conservation began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. While all the doses reported for 2003 at off-site locations were below the dose limit for members of the public, several locations that are considered to be potentially accessible to the public had results in excess of the limit. As in the past, doses above 100 mrem were associated with various sites located in access-restricted areas of the reservation. Significantly, DOE is currently removing the entire inventory of outdoor stored uranium hexafluoride from ETTP. This action will dramatically reduce gamma radiation levels at ETTP.

*Real Time Gamma Radiation* - The division maintained gamma exposure rate monitors at a background location (Fort Loudoun Dam), spent nuclear fuel wells at SWASA 5 North (ORNL), Y-12's Industrial Landfill, the 3513 Waste Holding Basin (ORNL), the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (Bear Creek Valley). Measurements collected from these sites ranged from 0 μR/hr to 1,764 μR/hr. The highest exposure rates were recorded at the boundary of a radiation area surrounding sediments dredged from the 3513 Waste Holding Basin. Dose rates at this location averaged 1,739 μR/hr, which is equivalent to 1.7 mrem/hr for gamma radiation. While not a DOE requirement, these values approach limits specified by state and Nuclear Regulatory Commission regulations requiring their licensees to conduct operations in such a manner that the external dose in any unrestricted area not exceed 2.0 mrem in any one hour.

*Vegetation bioaccumulation of radionuclides and metals* has been determined to warrant further investigations. Specifically, gross beta, zinc, arsenic, iron, chromium, lead, cobalt, copper, and nickel had elevated concentrations in several vegetation samples collected during 2003. Several aquatic vegetation samples (such as water cress) showed gross beta activities above Sr-90 activities being considered as draft policy guidance by the Food and Drug Administration. Concentrations suggest a correlation between groundwater and aquatic vegetation concentrations from the same spring monitoring locations. This project has inferences to both human and wildlife exposures.

*Radon in Bear Creek Burial* Grounds - In 2003, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) continued a pilot study designed to assess the feasibility of monitoring radon at burial grounds on DOE's Oak Ridge Reservation. The project was prompted by a concern that the disposal of large amounts of uranium in reservation burial grounds may have resulted in elevated radon levels (radon is produced by the natural decay of radionuclides in the uranium decay series). The results from the initial study in 2001 indicated radon levels could be measured using the technique developed for the project, but the loss of some of the detectors and damage to others by insects or small animals introduced uncertainties that limited the use of the data. It was subsequently decided to continue the study, but deploy the detectors during the winter/spring months in an effort to avoid some of the problems encountered in 2001. In February 2003, the second set of detectors was placed over the burial grounds in Bear Creek Valley, left in place for four months, them retrieved and analyzed. While the results for 2003 were much lower than those in 2001, data from both efforts indicated that radon can be measured using the techniques developed for the project and that the radioactive gas was higher over localized areas than the background measurements.

*Facility Surveys* - Like other Department of Energy research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The Program looks at facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. tornado) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the

*Tennessee Oversight Agreement,* which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 172 facilities and found that thirty five percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release relates to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). During 2003 the survey team evaluated four facilities and found that all four posed a high potential for environmental release. All four of these facilities were at Y-12 (9731, 9959, 9736, 9959-2). Staff also completed surveys of five additional facilities at Y-12 during 2003, but the final reports on these facilities are being held by Y-12 pending Official Use Only (OUO) classification discussion and review (9610, 9720-8, 9720-21, 9720-16, 9720-53). Consequently, these five facilities are not reported or recorded in this report. Since the inception of the program, DOE corrective actions (including demolitions) have removed ten facilities from the division's list of "high" Potential Environmental Release (PER) facilities.

Beginning in 2002 the Facility Survey Program staff also began organized document reviews and visits to facilities that were targeted for demolition at the ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. During 2003 staff made 269 visits before and during the demolition of 67 facilities.

*Needed Maintenance Actions on Otherwise Clean Areas* - The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20. The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR, which could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project. In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix I). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project revisited these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns.

*Free Release Inspections* - A total of 18 radiological free release inspections were conducted at the three facilities (ORNL, Y-12 and ETTP). The majority of those were at Y-12 and ORNL surplus sales prior to public auctions. The division had one significant finding from these inspections. A division radiological survey conducted at ORNL Surplus Sales during November 2003 revealed radiological contamination on a large impact wrench. After a re-survey by ORNL RCTs, the wrench was enclosed in bags to isolate the contamination and a radiological tag was applied to the wrench. Later the wrench was removed from the site to be disposed of as contaminated waste.

**Surface Water**

*General ambient surface water analysis* is a key component of environmental quality and impact assessment for rivers, streams, lakes, and impoundments. The DOE Oversight Division conducted sampling at 26 sites in 2003. The samples were analyzed for standard water quality parameters. Based on comparisons with the Tennessee Water Quality Criteria (TWQC) for recreation, none of the sites exceeded these criteria. It should be recognized that sites very close to or within contaminated burial areas were not part of this scope. Specialized surface water investigations aid in evaluating point and non-point sources.

*Bear Creek Uranium Transport* - In order to determine the fate and transport of uranium in the waters of Bear Creek Valley, quarterly samples and flow measurements were taken at various locations on Bear Creek and associated springs and tributaries. The flow measurements and the results of radiochemical analysis on the samples were used to calculate the flux of gross alpha moving through Bear Creek Valley. The flux data were then used to determine the movement and fate of uranium dissolved in the waters of the valley. The data indicates that most of the uranium in Bear Creek is delivered along discrete, low volume, high concentration flow paths, during the wetter parts of the year, suggesting that uranium inputs to the creek can be identified and controlled. In 2003, the data suggested that surface waters were the dominate pathway for the transport of uranium from the disposal sites through Bear Creek Valley and anthropomorphic activities may have resulted in a significant increase in the flux of dissolved uranium.

**Sediment**

*Sediment analysis* is a key component of environmental quality and impact assessment for aquatic ecosystems. The DOE Oversight Division conducted sediment sampling at 34 sites in 2003. The sediments were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations Office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish. For the contaminants that were analyzed, the sediments showed no levels of concern for human health. These samples were taken under ambient conditions and not near or within contaminated burial grounds.

## Conclusion

The 2003 monitoring results showed effort by DOE to improve the overall health of the public and the environment. Many of the pollutant anomalies measured were a result of remediation activities and resulting fugitive emissions. However, none of these resulted in an unacceptable risk to the public. The state recognizes that some releases are inevitable when environmental clean up is done. The overall benefit of cleanup out weighs the short-term negative impacts. There are still significant source terms of contaminants that could be released through failure of engineering and administrative controls. Additionally, sources of gamma radiation exposure still exist that must be effectively isolated from the public. Sources of contamination in the human food chain still exist as evidenced by the necessary confiscation of two harvested deer in 2003. It is necessary and prudent for the state and DOE to continue monitoring efforts to detect and evaluate as early as possible, potential releases and radiation that could affect the public.

## Introduction

The Tennessee Department of Environment and Conservation (TDEC), DOE Oversight Division in accordance with the Tennessee Oversight Agreement Attachment A.7.2.2, is providing an annual environmental monitoring report of the results of its monitoring and analysis activities during the calendar year of 2003 for public distribution. The division was established in 1991 to administer the Tennessee Oversight Agreement and the CERCLA required Federal Facility Agreement. These agreements are designed to assure the citizens of Tennessee that their health, safety, and environment are being protected through existing programs and substantial new commitments by the Department of Energy (DOE).

This report consists of a series of individual reports that involve independent environmental monitoring by the division. The individual reports are organized by general areas of interest: Surface Water; Drinking Water; Biological/Fish and Wildlife; Groundwater; Air Quality; and Radiation. Abstracts and conclusions are available in each report to provide a quick overview of the content and outcome of each monitoring effort. All supporting information and data used in the completion of these reports are available for review in the division's program files. Overall, the report characterizes and evaluates the chemical and radiological emissions in the air, water, and sediments both on and off the Oak Ridge Reservation.

TDEC has considered the location, environmental setting, history, and on-going DOE operations in its environmental monitoring programs. The information gathered provides a better understanding of the fate and transport of contaminants released from the Oak Ridge Reservation into the environment. This understanding has led to the development of an ambient monitoring system and increased the probability of detecting releases in the event that institutional controls on the Oak Ridge Reservation fail.

Currently, TDEC's monitoring activities have not detected any imminent threats to public health or the environment outside of the Oak Ridge Reservation. However, unacceptable releases of contaminants from past DOE operational and disposal activities continue to pose risk to the environment and it is imperative to note that if current institutional controls fail or if the present contaminant source controls can no longer be maintained, the public would be at risk of environmental contamination.

## Site Description

The DOE Oak Ridge Reservation (ORR), as shown in Figure 1, encompasses approximately 35,000 acres and three major operational DOE facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Y-12 Plant (Y-12), and the East Tennessee Technology Park (ETTP, formerly the K-25 Gaseous Diffusion Plant). The initial objectives of the ORR operations were the production of plutonium and the enrichment of uranium for nuclear weapons components. In the 60+ years since the ORR was established, a variety of production and research activities have generated numerous radioactive, hazardous, and mixed wastes. These wastes, along with wastes from other locations, were disposed of on the ORR. Early waste disposal methods on the ORR were rudimentary compared to today's standards.

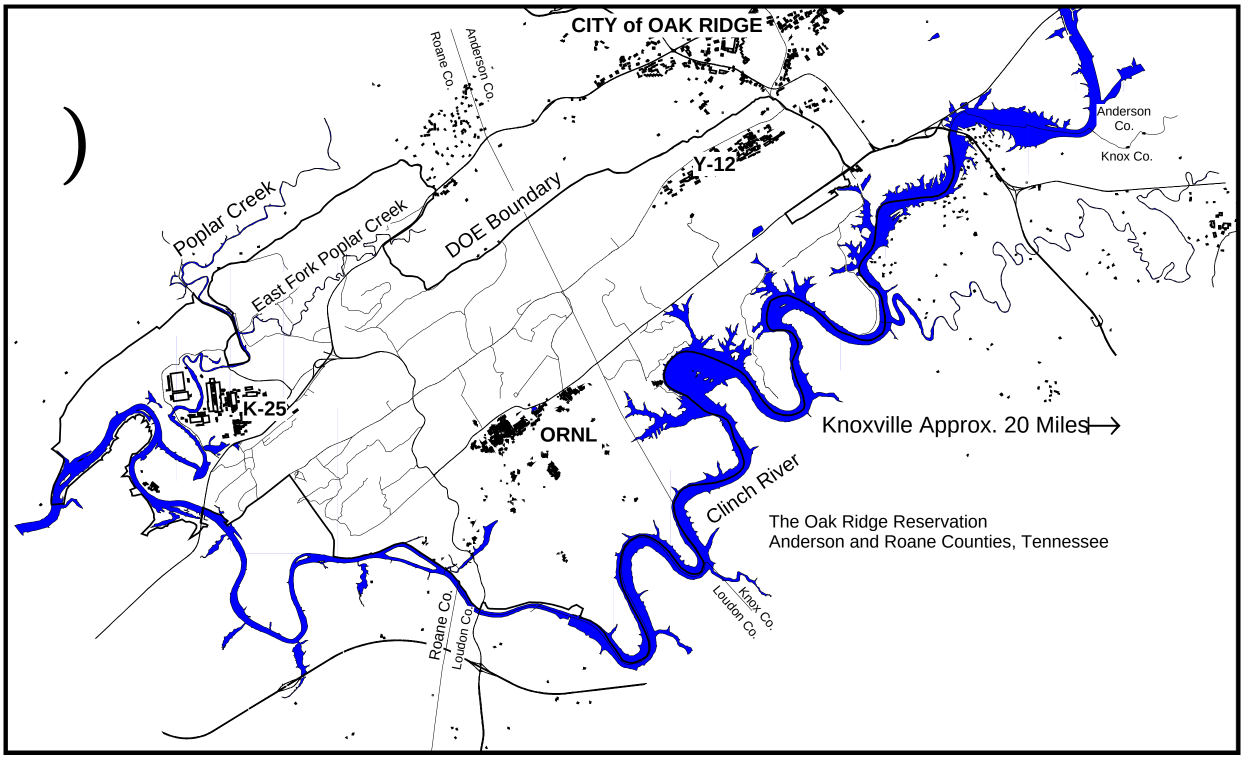


**Figure 1: The Oak Ridge Reservation**

The ORR is located within the corporate boundaries of the city of Oak Ridge, Tennessee, in the counties of Anderson and Roane. The Reservation is bounded on the north and east by residential areas of the city of Oak Ridge and on the south and west by the Clinch River. Counties adjacent to the Reservation include Knox, Loudon, and Morgan. Meigs and Rhea counties are immediately downstream on the Tennessee River from the ORR. The nearest cities are Oak Ridge, Oliver Springs, Kingston, Lenoir City, Harriman, Farragut, and Clinton. The nearest metropolitan area, Knoxville, lies approximately 20 miles to the east. Figure 2 depicts the general location of the Oak Ridge Reservation and nearby cities.

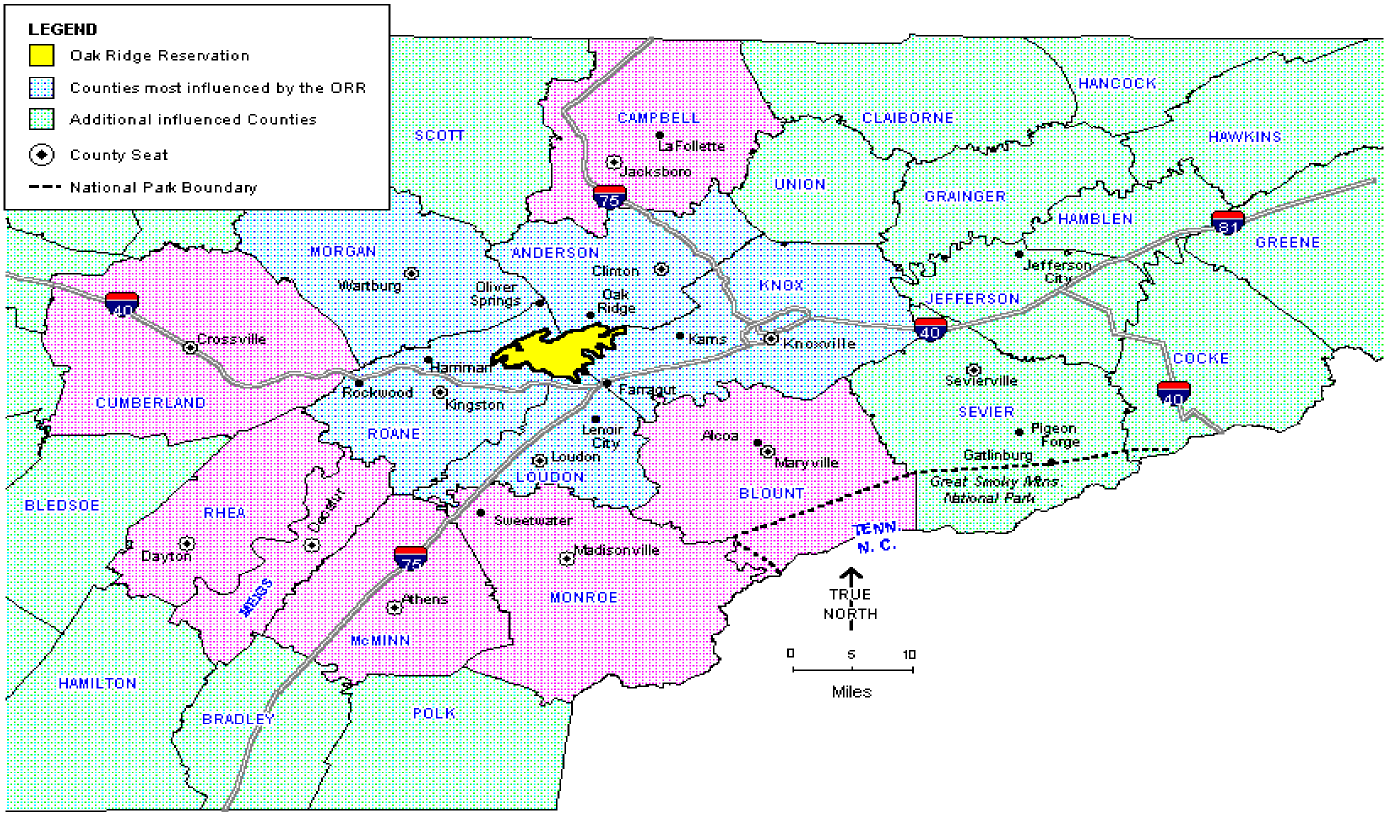


**Figure 2: Location of the Oak Ridge Reservation**

The ORR lies in the Valley and Ridge Physiographic Province of East Tennessee. The Valley and Ridge Province is a zone of complex geologic structures dominated by a series of thrust faults and characterized by a succession of elongated southwest-northeast trending valleys and ridges. In general, the ridges are underlain by sandstones, limestones, and/or dolomites that are relatively resistant to erosion. Weaker shales and more soluble carbonate rock units underlie the valleys.

The hydrogeology of the ORR is very complex with a number of variables influencing the direction, quantity, and velocity of groundwater flow that may or may not be evident from surface topography. In many areas of the ORR, groundwater appears primarily to travel along short flow paths in the storm flow zone to nearby streams. In other areas, evidence indicates substantial groundwater flow and, thereby, contaminant transport may occur preferentially in fractures and solution cavities in the bedrock for relatively long distances.

As seen in Figure 3, streams on the ORR drain to the Clinch River. Melton Hill Dam impounded the Clinch River in 1963. Contaminants released on the Oak Ridge Reservation enter area streams (e.g., White Oak Creek, Bear Creek, East Fork Poplar Creek, and Poplar Creek) and are transported into the Clinch River and Watts Bar Reservoir on the Tennessee River.

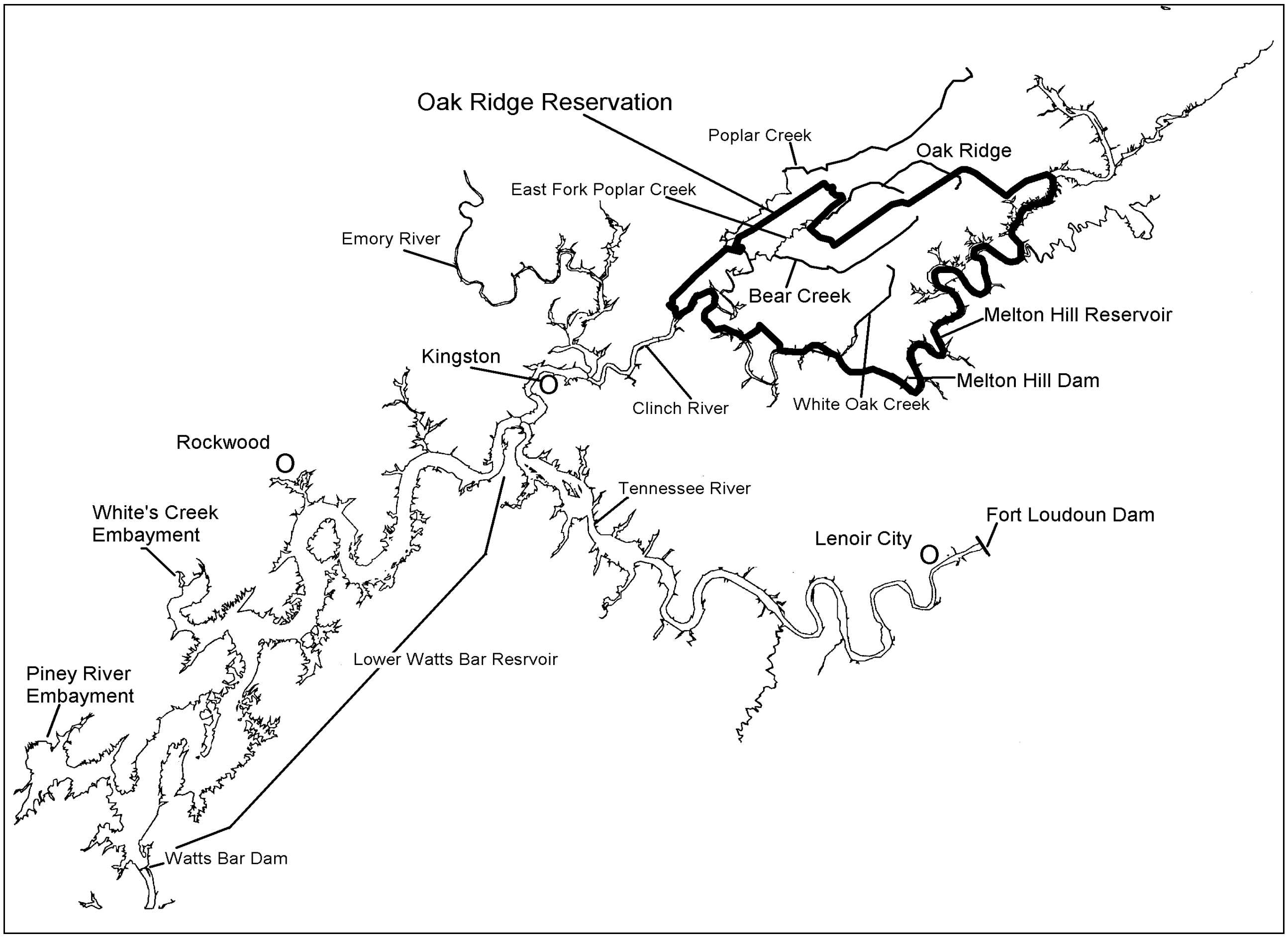


**Figure 3: Watts Bar Reservoir**

The climate of the region is moderately humid and the annual average precipitation is around 55 inches. Winds on the reservation are controlled, in large part, by the valley and ridge topography with prevailing winds moving up the valleys (northeasterly) during the daytime and down the valleys (southwesterly) at night.

# CHAPTER 1 AIR QUALITY MONITORING

## Hazardous Air Pollutants Metals Monitoring on East Tennessee Technology Park

Principal Authors: Ashwin Brahmbhatt, Len Berry

**Abstract**

The Tennessee Department of Environment and Conservation Department of Energy Oversight Division's (the division) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring at the East Tennessee Technology Park (ETTP) and to verify the Department of Energy's (DOE) reported monitoring results. Monitoring was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel, and Uranium as a metal.

The results of the 2003 monitoring campaign conducted by the division at the ETTP sites indicate no apparent elevated levels of HAPs metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

It should also be noted that other incinerator facilities are in the vicinity of the Oak Ridge Reservation (ORR). The possibility exists that these operations, along with the TVA Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant, could have an impact on the ambient air around the ORR. Operations at the TSCA Incinerator cannot be singled out as the sole contributor of levels seen in the analytical results from the ETTP or the ORR in general.

Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by the division. This project will continue to monitor for potential effects on the ORR at ETTP in order to provide independent monitoring to assure protection of human health and the environment.

**Introduction**

Title III of the Clean Air Act Amendments (CAAAs) has identified 189 toxic chemicals. These chemicals, called HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries, including printing, metal fabrication, auto body repair, automotive repair, wood finishing, dry cleaning and others. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than NESHAPs for each pollutant, the 1990 CAAAs direct EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, the division's Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data were collected at a site located near Norris Lake. These data were used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in

1999 to the list of metals of concern. Future Decontamination and Decommissioning (D&D) activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by the division.

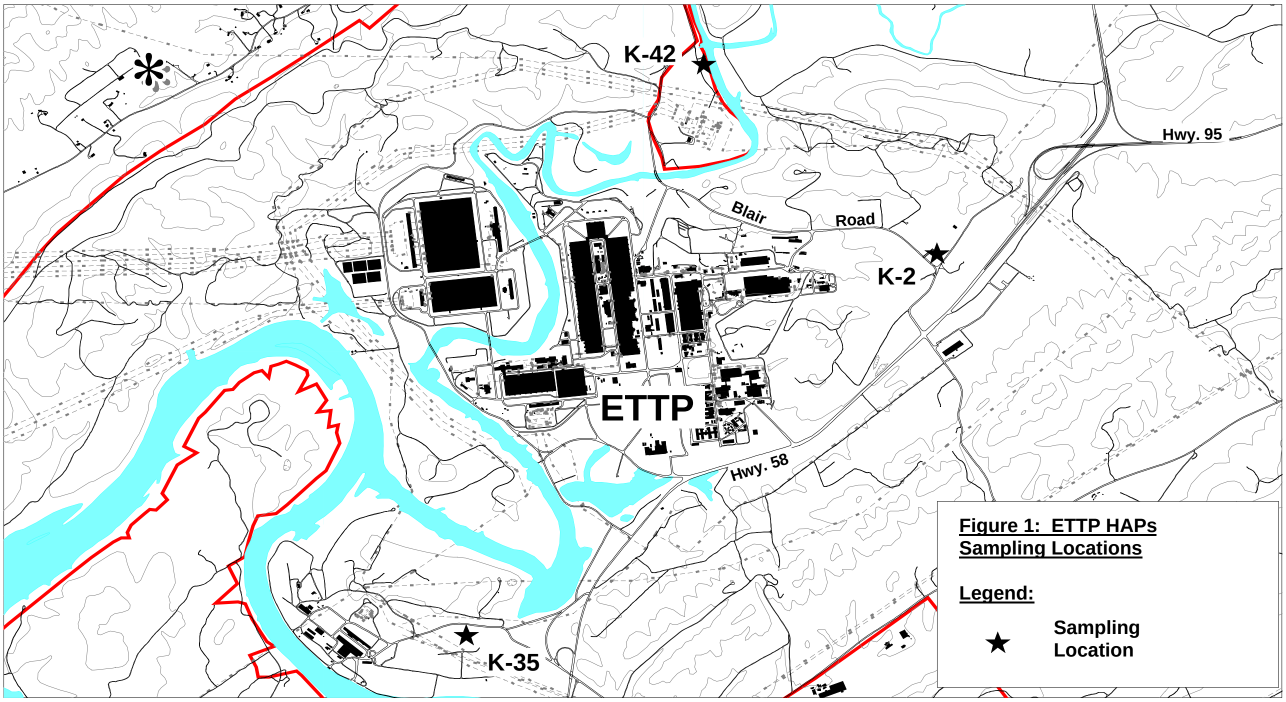


**Figure 1. ETTP**

## Methods and Materials

The ambient air sampling for this project was conducted at stations K-2 (Blair Rd opposite the TSCA Incinerator), station K-42 co-located with DOE Perimeter Air Monitor (PAM) 42 (next to Poplar Creek) and station K-35 co-located with DOE Perimeter Air Monitor (PAM) 35 (Gallaher Rd Bridge area). The locations of these monitoring stations are shown in Figure 1. The same sites were also utilized for the previous division monitoring campaigns.

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of the division's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR. Additional factor in selecting these locations was an availability of power source.

The project was conducted as closely as possible to the established 2003 sampling project schedule. This schedule was modified as needed to accommodate numerous power outages caused by construction near the K-42 site, and other events that effected movement of the samplers. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis.

The principal parameters monitored during 2003 were arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium. Uranium was analyzed as a metal (by inorganic method).

The ambient air sampling schedule is listed in Table 1.

**Table 1.**
**2003 HAPs metals ambient air sampling schedule**

| Monitoring period[1] | Sampling Locations | Sampling period | Collection frequency | Analysis frequency |
|---|---|---|---|---|
| 01/07/03-02/18/03 | K-42 | Continuous | Weekly | Weekly |
| 03/11/03-04/30/03 | K-2 | Continuous | Weekly | Weekly |
| 05/13/03-06/03/03 | K-35 | Continuous | Weekly | Weekly |
| 06/10/03-07/08/03 | K-42 | Continuous | Weekly | Weekly |
| 07/15/03-08/12/03 | K-2 | Continuous | Weekly | Weekly |
| 08/19/03-09/10/03 | K-35 | Continuous | Weekly | Weekly |
| 09/16/03-10/16/03 | K-42 | Continuous | Weekly | Weekly |
| 10/21/03-11/24/03 | K-2 | Continuous | Weekly | Weekly |
| 12/02/03-12/31/03 | K-35 | Continuous | Weekly | Weekly |

**[1]Sampler rotated between K-2, K-42, and K-35 monitoring locations.**

## Results and Discussion

Quarterly lead results were determined from analyses of continuous weekly samples from stations K-2, K-35, and K-42. Lead analytical results are summarized in Table 2 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$. The results obtained indicate that this value was only 0.27% of the quarterly standard.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2003 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2002 ASER, indicating comparable levels of HAPs in the ambient air in and around the ORR.

**Table 2.**
**2003 Lead concentration in ambient air at the ETTP**

| **Station** | **Quarterly averages of weekly samples ($\mu g/m^3$)** | | | | **Max quarterly result ($\mu g/m^3$)** | **Max weekly result ($\mu g/m^3$)** | **Max percent of quarterly standard ($\mu g/m^3$)[a]** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | | | |
| K-2 | 0.0035 | 0.0037 | 0.0025 | 0.0040 | 0.0040 | 0.0070 | 0.27 |
| K-35 | *b* | 0.0025 | 0.0033 | 0.0028 | 0.0033 | 0.0040 | 0.22 |
| K-42 | 0.0027 | *b* | 0.0018 | 0.0025 | 0.0027 | 0.0030 | 0.18 |
| Quarterly avg. | 0.0031 | 0.0031 | 0.0025 | 0.0031 | 0.0031 | N/A | 0.214 |
| Quarterly max | 0.0035 | 0.0037 | 0.0033 | 0.0040 | 0.0040 | N/A | 0.27 |
| Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$ | | | | | | | |
| Annual average for all stations = 0.0030 $\mu g/m^3$ | | | | | | | |

**[a] Tennessee and national air quality standard for lead is 1.5 $\mu g/m^3$ quarterly arithmetic average.**
**[b] This station was not monitored this quarter**.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples from stations K-2, K-35, and K-42. These analytical results are summarized in Table 3. There are no Tennessee or national ambient air quality standards for these hazardous air pollutants. The annual average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266.

**Table 3.**
**2003 Hazardous air pollutant carcinogenic metals concentration in ambient air at ETTP**

| HAPs | Ambient air concentration (μg/m$^3$) | | | Annual concentration guideline (μg/m$^3$) | Percentage of standard (guideline) |
|---|---|---|---|---|---|
| | Annual avg. | Weekly max | Max location | | |
| Arsenic | U | U | | 0.0023[a] | 0 |
| Beryllium | U | U | | 0.004[a] | 0 |
| Cadmium | U | U | | 0.0056[a] | 0 |
| Chromium | U | U | | 0.00083[a] Cr-VI<br>1000.0[a] Cr-III | 0 |
| Nickel | 0.00030 | 0.0030 | K-42, K-2, K-35 | 0.042[a] | 0.71 |
| Uranium | U | U | | 0.15[b] | 0 |

**U – Analyte not detected in laboratory analysis**
**a Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266.**
**b DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/m3, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% 235U.**

There were no detected concentrations of arsenic, beryllium, cadmium, chromium or uranium. The annual average result for nickel was 0.00030 μg/m3, well below the risk-specific dose of 0.042 μg/m3.

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2003 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2001 ASER. The 2001 ASER indicated detection of hazardous air pollutant carcinogenic metals with all of them below the risk-specific doses. The maximum monthly concentrations of cadmium reported in 2002 ASER were in the vicinity of the ETTP steam plant and arsenic, beryllium and chromium at the K-770 scrap yard, locations that were not monitored by this DOE Oversight division's independent environmental project. Nickel was not included as a monitoring parameter in 2002 ASER. The maximum concentration of uranium was reported, by DOE in the 2001 ASER, as less than 1% of Derived Concentration Guide of 0.15μg/m3.

## Conclusion

The results of the 2003 monitoring campaign conducted by the division at the ETTP sites indicate no apparent elevated levels of for hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

It should also be noted that other incinerator facilities are in the vicinity of the ORR. The possibility exists that these operations, along with the TVA Bull Run Steam Plant facility on Edgemoor Road and the Kingston Steam Plant could have an impact on the ambient air around the

ORR. Operations at the TSCA Incinerator cannot be singled out as the sole contributor of levels seen in the analytical results from the ETTP or the ORR in general.

This project has been re-authorized to continue into 2004. Sampling sites will remain as they have for the year 2003. Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by the division.

**References**


Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model 2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee. 2001.

Yard, C.R. 2002. *Health, Safety and Security Plan,* Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee.

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# CHAPTER 1 AIR QUALITY MONITORING

## Hazardous Air Pollutants Metals Monitoring on Y-12 and ORNL (X-10)

Principal Authors: Ashwin Brahmbhatt, Len Berry

**Abstract**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Hazardous Air Pollutant (HAPs) Monitoring Program was developed to provide continued independent monitoring at the Oak Ridge National Laboratory (ORNL) and Y-12 National Security Complex (Y-12) to verify the Department of Energy's (DOE) reported monitoring results. Monitoring was conducted for Arsenic, Beryllium, Cadmium, Total Chromium, Lead, Nickel, and Uranium as a metal.

The results of the 2003 monitoring campaign conducted by the division at the Y-12 and ORNL sites indicate no apparent elevated levels of HAPs metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by TDEC. This project will continue to monitor for potential effects on the ORR at Y-12 and ORNL in order to provide independent monitoring to assure protection of human health and the environment.

**Introduction**

Title III of the Clean Air Act Amendments (CAAAs) has identified 189 toxic chemicals. These chemicals, called HAPs, are known or suspected carcinogens, and have high usage and emissions in a wide variety of industries, including printing, metal fabrication, auto body repair, automotive repair, wood finishing, dry cleaning and others. Major stationary sources of HAPs are subject to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) found in Title III of the CAAAs of 1990. Rather than NESHAPs for each pollutant, the 1990 CAAAs direct EPA to set technology-based standards using maximum achievable control technologies (MACT) for 175 source categories which will require sharp reductions of routine emissions of toxic air pollutants.

In 1997, concerns were raised by members of the public regarding potential health effects due to possible concentrations of HAPs in the ambient air on and around ORR. In response to these concerns, the division's Waste Management (WM) program developed an ambient air monitoring program for the ORR in order to determine what effects, if any, DOE operations were having on the ambient air on and around the reservation with regard to HAPs. This program was designed to provide an independent verification of monitoring results as reported by the DOE. Background data were collected at a site located near Norris Lake. These data were used in a comparative manner as a baseline for the area surrounding the ORR. Nickel and Uranium as a metal were added in 1999 to the list of metals of concern. Future Decontamination and Decommissioning (D&D) activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by the division.

**ORNL**

Monitoring at ORNL was conducted at stations located at both the east and west ends of this facility. The western site is co-located at the Perimeter Air Monitor (PAM) 3 off Bethel Valley

Road. The monitor at the east-end of ORNL is co-located with Meteorological Tower 3. See Figure 1.

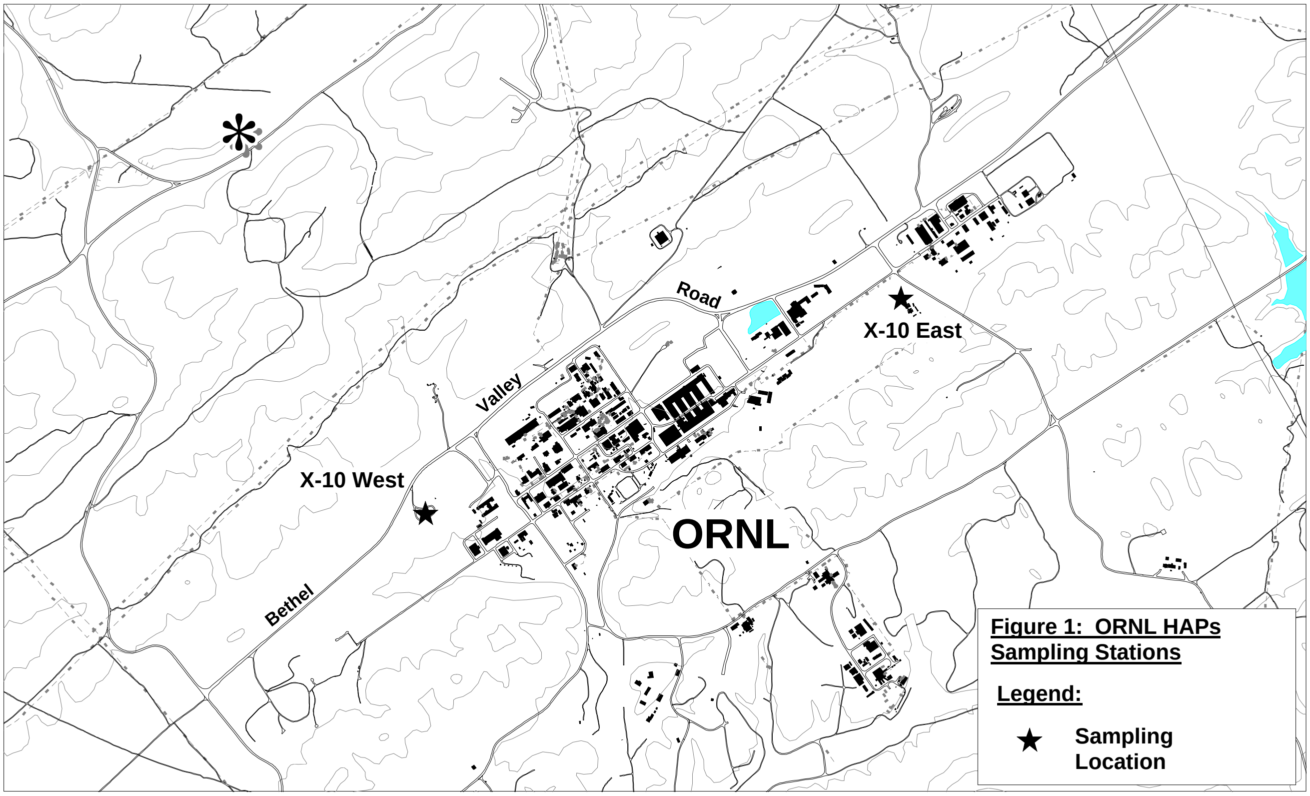


**Figure 1.**

**Y12**

Monitoring at Y-12 was conducted at stations located at both the east and west ends of this facility. The site at the west-end of Y-12 is co-located with Meteorological Tower 6 on Bear Creek Valley Road. The monitoring site at the east-end of Y-12 is co-located with Meteorological Tower 5. See Figure 2.

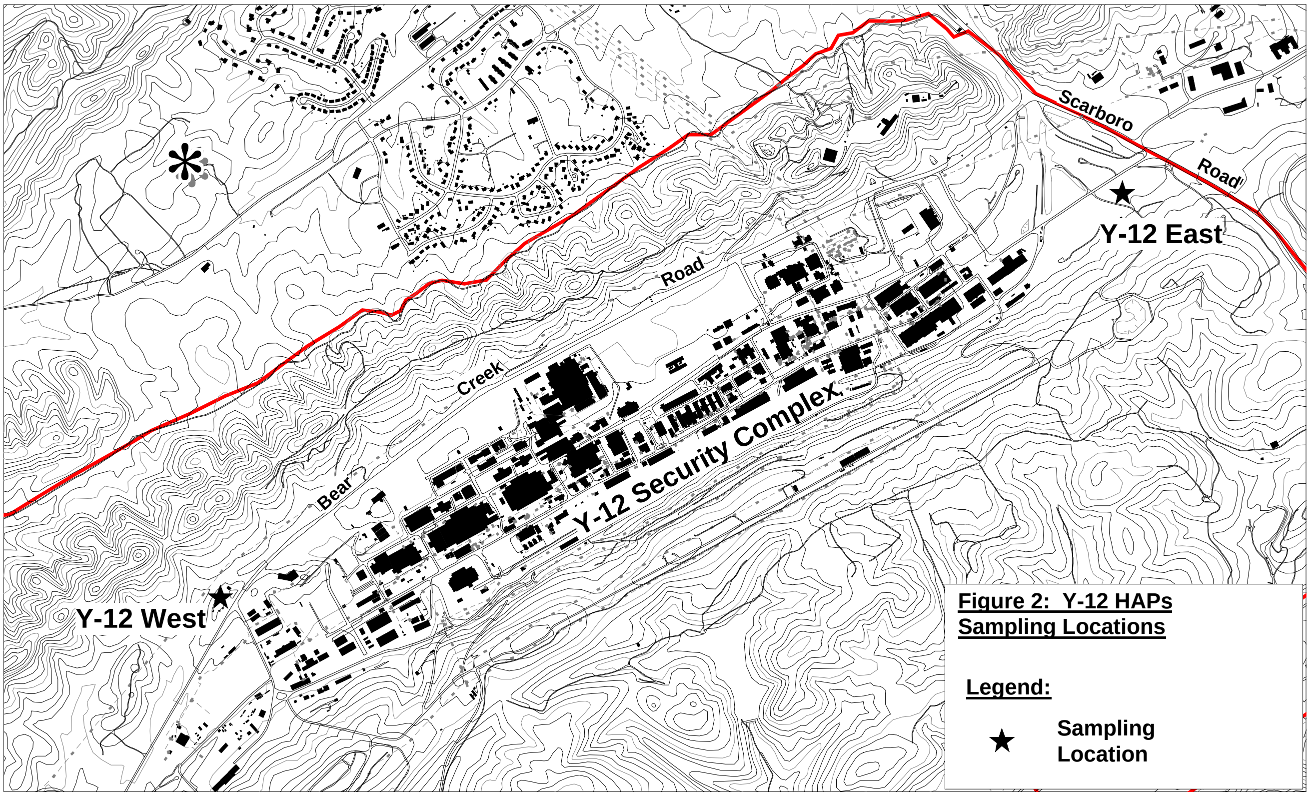


**Figure 1**

## Methods and Materials

The monitoring sites selected were chosen based upon windroses data that indicated the sites were in the prevailing wind flow patterns for the region surrounding the ORR. The windflow during the day is a southwest to northeast pattern while during the night; the flow pattern is reversed. The placement then of the division's monitors allowed for sampling that would be representative of a 24-hour windflow pattern at the ORR. Additional factor in selecting these locations was an availability of power source.

The project was conducted as closely as possible to the established 2003 sampling project schedule. Filter samples were collected on a weekly basis and mailed to the state laboratory in Nashville for analysis.

The principal parameters monitored during 2003 were arsenic, beryllium, cadmium, total chromium, lead, nickel, and uranium. Uranium was analyzed as a metal (by inorganic method). The ambient air sampling schedules for ORNL and Y-12 are listed in Table 1 and Table 2, respectively.

## Results and Discussion

**Table 1.**
**HAPs metals ambient air sampling schedule, 2003 at ORNL**

| Monitoring period[1] | Sampling Locations | Sampling period | Collection frequency | Analysis frequency |
|---|---|---|---|---|
| 01/01/03-03/11/03 | X-10 W | Continuous | Weekly | Weekly |
| 03/18/03-06/05/03 | X-10 E | Continuous | Weekly | Weekly |
| 06/10/03-07/08/03 | X-10 W | Continuous | Weekly | Weekly |
| 07/15/03-08/12/03 | X-10 E | Continuous | Weekly | Weekly |
| 08/19/03-09/10/03 | X-10 W | Continuous | Weekly | Weekly |
| 09/16/03-10/16/03 | X-10 E | Continuous | Weekly | Weekly |
| 11/06/03-11/24/03 | X-10 W | Continuous | Weekly | Weekly |
| 12/02/03-12/31/03 | X-10 E | Continuous | Weekly | Weekly |

**[1]Sampler rotated between X-10 E and X-10 W monitoring locations.**

**Table 2.**
**HAPs metals ambient air sampling schedule, 2003 at Y-12**

| Monitoring period[1] | Sampling Locations | Sampling period | Collection frequency | Analysis frequency |
|---|---|---|---|---|
| 01/07/03-04/30/03 | Y-12 W | Continuous | Weekly | Weekly |
| 05/13/03-05/28/03 | Y-12 E | Continuous | Weekly | Weekly |
| 06/10/03-07/01/03 | Y-12 W | Continuous | Weekly | Weekly |
| 07/23/03-08/12/03 | Y-12 E | Continuous | Weekly | Weekly |
| 08/27/03-09/10/03 | Y-12 W | Continuous | Weekly | Weekly |
| 09/16/03-10/07/03 | Y-12 E | Continuous | Weekly | Weekly |
| 11/06/03-11/24/03 | Y-12 W | Continuous | Weekly | Weekly |
| 12/02/03-12/17/03 | Y-12 E | Continuous | Weekly | Weekly |

**[1]Sampler rotated between Y-12 E and Y-12 W monitoring locations.**

Quarterly lead results were determined from analyses of continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. Lead analytical results are summarized in Table 3 and Table 4 and are compared with the Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$. At ORNL the results obtained indicate that this value was only 0.33% of the quarterly standard. At Y-12 the results obtained indicate that this value was only 0.22% of the quarterly standard.

**Table 3.**
**Lead concentration in ambient air at ORNL, 2003**

| Station | Quarterly averages of weekly samples ($\mu g/m^3$) 1 | 2 | 3 | 4 | Max quarterly result ($\mu g/m^3$) | Max weekly result ($\mu g/m^3$) | Max percent of quarterly standard ($\mu g/m^3$)[a] |
|---|---|---|---|---|---|---|---|
| X-10 E | 0.0050 | 0.0027 | 0.0030 | 0.0020 | 0.0050 | 0.0070 | 0.33 |
| X-10 W | 0.0023 | 0.0025 | 0.0030 | 0.0033 | 0.0033 | 0.0040 | 0.22 |
| Quarterly avg. | 0.0037 | 0.0026 | 0.0030 | 0.0027 | 0.0037 | N/A | 0.25 |
| Quarterly max | 0.0050 | 0.0027 | 0.0030 | 0.0033 | 0.0050 | N/A | 0.33 |
| Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$ | | | | | | | |
| Annual average for all stations = 0.0030 $\mu g/m^3$ | | | | | | | |

[a] **Tennessee and national air quality standard for lead is 1.5 $\mu g/m^3$ quarterly arithmetic average.**

**Table 4.**
**Lead concentration in ambient air at Y-12, 2003**

| Station | Quarterly averages of weekly samples ($\mu g/m^3$) 1 | 2 | 3 | 4 | Max quarterly result ($\mu g/m^3$) | Max weekly result ($\mu g/m^3$) | Max percent of quarterly standard ($\mu g/m^3$)[a] |
|---|---|---|---|---|---|---|---|
| Y-12 E | *b* | 0.0023 | 0.0033 | 0.0027 | 0.0033 | 0.0050 | 0.22 |
| Y-12 W | 0.0026 | 0.0022 | 0.0030 | 0.0027 | 0.0030 | 0.0030 | 0.20 |
| Quarterly avg. | 0.0026 | 0.0023 | 0.0032 | 0.0027 | 0.0023 | N/A | 0.21 |
| Quarterly max | 0.0026 | 0.0023 | 0.0033 | 0.0027 | 0.0033 | N/A | 0.22 |
| Tennessee and national quarterly ambient air quality standard of 1.5 $\mu g/m^3$ | | | | | | | |
| Annual average for all stations = 0.0027 $\mu g/m^3$ | | | | | | | |

[a] **Tennessee and national air quality standard for lead is 1.5 $\mu g/m^3$ quarterly arithmetic average.**
[b] **This station was not monitored this quarter.**

At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2003 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2002 ASER, indicating comparable levels of HAPs in the ambient air in and around the ORR.

Analyses of hazardous air pollutant carcinogenic metals (arsenic, beryllium, cadmium, chromium, and nickel) were performed on all collected continuous weekly samples from stations X-10 E and X-10 W at ORNL and from stations Y-12 E and Y-12 W at the Y-12 site. These analytical results are summarized in Table 5 and Table 6. There are no Tennessee or national ambient air quality standards for these hazardous air pollutants. The annual average concentrations were compared to risk specific doses and reference air concentrations as listed in 40 CFR 266.

There were no detected concentrations of arsenic, beryllium, cadmium, and uranium. The annual average result for nickel at X-10 was 0.0004 $\mu g/m^3$ and it was 0.0002 $\mu g/m^3$ at Y-12, well below the risk-specific dose of 0.042 $\mu g/m^3$. The annual average result for chromium at X-10 was 0.0001 $\mu g/m^3$, well below the risk specific dose of 0.00083 for Cr VI and 1000.0 for Cr III. At Y-12 it was undetected. At the time of this report, the ORR Annual Site Environmental Report (ASER) for 2003 was not available. However, analytical results from the 2001, 2002 and 2003 HAPs monitoring program were compared with the 2002 ASER. The 2002 ASER indicated detection of hazardous air pollutant carcinogenic metals with all of them below the risk-specific doses. Nickel was not included as a monitoring parameter in 2001 ASER. The maximum concentration of uranium was reported, by DOE in the 2002 ASER, as less than 1% of Derived Concentration Guide of 0.15μg/$m^3$.

**Table 5.**
**2003 Hazardous air pollutant carcinogenic metals concentration in ambient air at ORNL**

| HAPs | Ambient air concentration (μg/$m^3$) | | | Annual concentration guideline (μg/$m^3$) | Percentage of standard (guideline) |
|---|---|---|---|---|---|
| | Annual avg. | Weekly max | Max location | | |
| Arsenic | U | U | | 0.0023[a] | 0 |
| Beryllium | U | U | | 0.004[a] | 0 |
| Cadmium | U | U | | 0.0056[a] | 0 |
| Chromium | 0.0001 | 0.002 | X-10 E | 0.00083[a] Cr-VI<br>1000.0[a] Cr-III | 12.0 for Cr VI<br>0 for Cr III |
| Nickel | 0.0004 | 0.009 | X-10 E | 0.042[a] | 0.95 |
| Uranium | U | U | | 0.15[b] | 0 |

**U – Analyte not detected in laboratory analysis**
**[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266**
**[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/$m^3$, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/$m^3$ assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% $^{235}$U.**

**Table 6.**
**2003 Hazardous air pollutant carcinogenic metals concentration in ambient air at Y-12**

| HAPs | Ambient air concentration (μg/$m^3$) | | | Annual concentration guideline (μg/$m^3$) | Percentage of standard (guideline) |
|---|---|---|---|---|---|
| | Annual avg. | Weekly max | Max location | | |
| Arsenic | U | U | | 0.0023[a] | 0 |
| Beryllium | U | U | | 0.004[a] | 0 |
| Cadmium | U | U | | 0.0056[a] | 0 |
| Chromium | U | U | | 0.00083[a] Cr-VI<br>1000.0[a] Cr-III | 0 for Cr VI<br>0 for Cr III |
| Nickel | 0.0002 | 0.002 | Y-12 E | 0.042[a] | 0.48 |
| Uranium | U | U | | 0.15[b] | 0 |

**U – Analyte not detected in laboratory analysis**
**[a] Risk-specific doses for As, Be, Cd, Cr-VI, and Ni and the reference air concentration for Cr-III as listed in 40 CFR 266**
**[b] DOE Order 5400.5 Derived Concentration Guide (DCG) for naturally occurring uranium is an annual concentration of 1E-01 pCi/$m^3$, which is equivalent to 100 mrem annual inhalation dose. This is equivalent to 0.15 ug/m3 assuming mass-to-curie concentration conversion for natural uranium assay of 0.717% 235U**.

## Conclusion

The results of the 2003 monitoring campaign conducted by the division at ORNL and Y-12 sites indicate no apparent elevated levels of hazardous air pollutants (HAPs) metals of concern. Analyses for all metals of concern were below guidelines, and/or detection limits of laboratory analysis.

This project has been re-authorized to continue into 2004. Sampling sites will remain as they have for the year 2003. Future D&D activities that could possibly generate emissions of HAPs will continue to be evaluated and monitored as required by the division.

## References


Boiler and Industrial Furnace Regulations - 40 CFR Part 266 Appendix V.

Draft New York State Air Guide-1, Guidelines for the Control of Toxic Ambient Air Contaminants, Appendix B of Air Guide-1, Ambient Air Quality Impact Screening Analyses, 1994 Edition.

Operations Manual for GMW Model2000H Total Suspended Particulate Sampling System, 1998 Graseby GMW Variable Resistance Calibration Kit # G2835.

TDEC/DOE-O Procedure number: SOP-ES&H-004 Air Monitoring/Air Sampling.

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee. 2001.

Yard, C.R. 2002. *Health, Safety and Security Plan*, Tennessee Department of Environment and Conservation Department of Energy Oversight Division, Oak Ridge, Tennessee

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# CHAPTER 1 AIR QUALITY MONITORING

## Environmental Radiation Ambient Monitoring System (ERAMS) Air Program

Principal Authors: James L. Dunlap, Howard Crabtree

**Abstract**

The Environmental Protection Agency's Environmental Radiation Ambient Monitoring System (ERAMS) is designed to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (EPA, 1988). This program provides radiochemical analysis of air samples taken from five air monitoring stations located on the Oak Ridge Reservation. In this effort, samples are collected twice weekly at each station by personnel from the Tennessee Department of Environment and Conservation to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. The results are provided to the State and published in a quarterly EPA report, *Environmental Radiation Data*. In 2003, the ERAMS results from each station exhibited similar trends and concentration. While slightly higher results were reported at monitoring locations near the Y-12 National Nuclear Security Complex, the available ERAMS results for 2003 do not indicate a significant impact on the environment or public health from ORR emissions.

**Introduction**

In the past, air emissions from Department of Energy (DOE) activities on the Oak Ridge Reservation (ORR) have been believed to be a potential cause of illnesses affecting area residents. While these emissions have substantially decreased over the years, concerns have remained that air pollutants from current activities (e.g., incineration of radioactive wastes, production of radioisotopes, and remedial activities) could pose a threat to public health and/or the surrounding environment. As a consequence, the Tennessee Department of Environment and Conservation (TDEC) has implemented three air monitoring programs to assess the impact of ORR air emissions on the surrounding environment and the effectiveness of DOE controls and monitoring systems. TDEC's Perimeter and Fugitive Air Monitoring Programs (described in associated reports) focus on monitoring exit pathways, non-point sources of emissions, and sites of special interest. TDEC's participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring System (ERAMS) supplements the other programs and provides verification of state and DOE monitoring.

EPA's ERAMS program is comprised of a national network of monitoring stations that regularly collect samples of air, water, and milk for radiochemical analysis. Historically, this network has been used to track environmental releases of radioactivity from nuclear weapons tests and nuclear accidents. In response to TDEC requests and an initiative to incorporate site specific monitoring into the program, EPA agreed to locate five air monitoring stations on the ORR in December 1994. These stations began operation in 1996.

**Methods and Materials**

The approximate locations of the five ERAMS samplers are provided in Figure 1 and EPA's analytical parameters are listed Table 1. The ERAMS samplers run continuously, collecting suspended particulates on filters as air is pulled through the units by a pump. TDEC staff collect these synthetic fiber filters from each sampler twice weekly, estimate the radioactivity on each using TDEC equipment, then ship the filters to EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama, for analysis.

NAREL performs gross beta analysis on each sample collected. Where the gross beta result exceeds one picocurie per meter cubed (pCi/$m^3$), additional analysis (gamma spectrometry) is performed to identify gamma emitters that may be present in the sample. Analysis for uranium and plutonium isotopes are performed semiannually on a composite of air filters collected during the previous semester. The results of the NAREL analysis are provided to TDEC staff and published in quarterly reports (*Environmental Radiation Data*), which are available on NAREL's internet web site (http://www.epa.gov/narel/erams.html).

In 2003, none of the gross beta results reported for the program exceeded the NAREL screening level that would have required analysis by gamma spectrometry. The 2003 results for uranium and plutonium analysis performed semiannually on composites of the air filters for each monitoring station was not available at the time of this report.

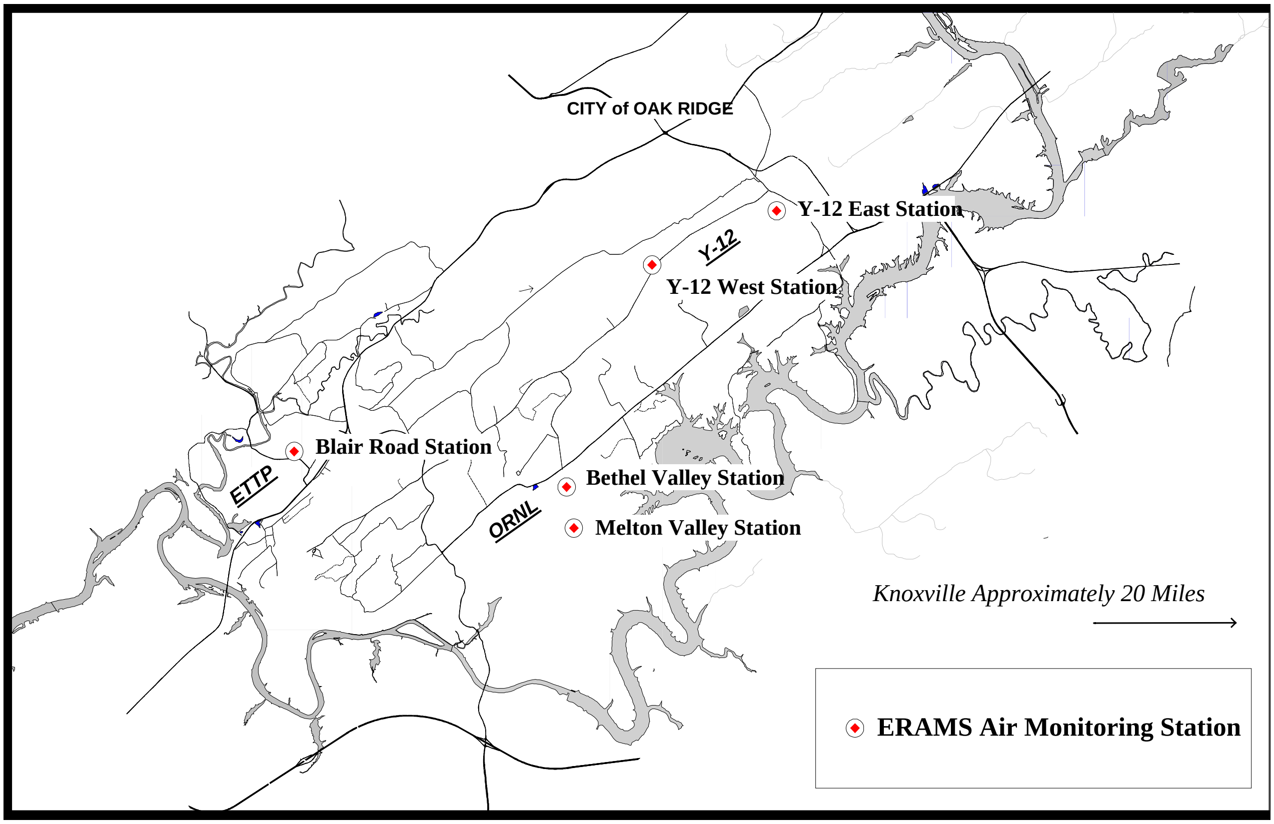



**Figure 1: Approximate Locations of Air Stations Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System on the Oak Ridge Reservation**

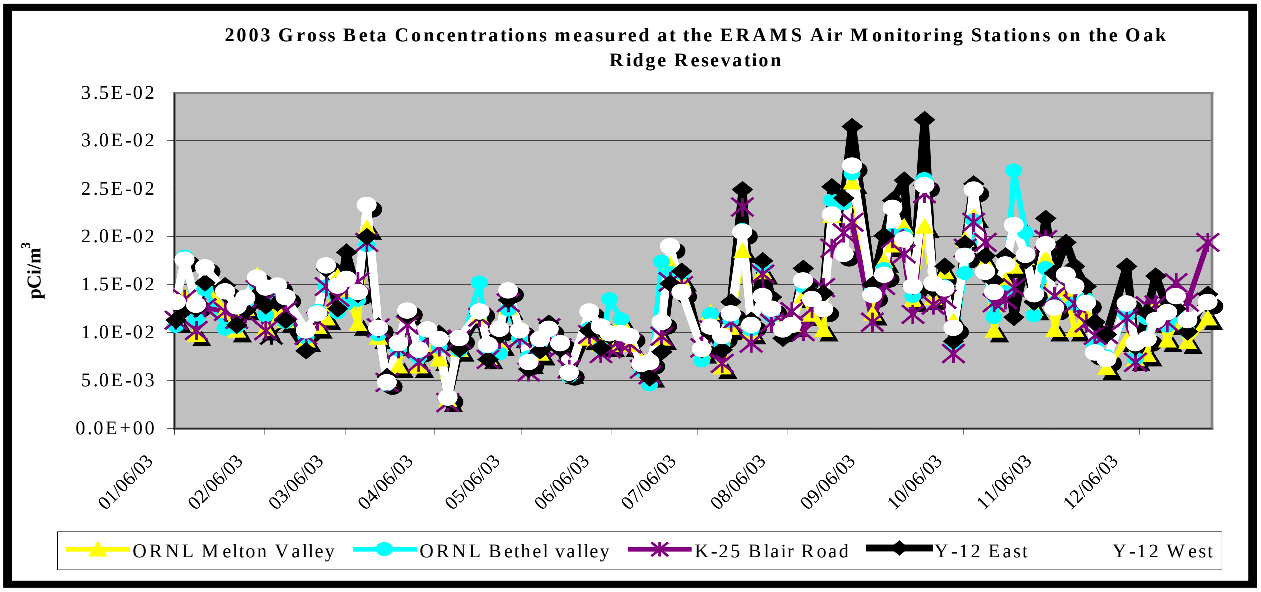
**Table 1: EPA Analysis of Air Samples Taken in Association with the Environmental Radiation Ambient Monitoring System**

| **ANALYSIS** | **FREQUENCY** |
|---|---|
| Gross Beta | Each of twice weekly samples |
| Gamma Scan | Samples showing greater than 1 pCi/$m^3$ of gross beta |
| Plutonium-238, Plutonium-239, Plutonium-240, Uranium-234, Uranium-235, Uranium-238 | Semiannually on composite air particulate filters |

## Results and Discussion

As can be seen in Figure 2, the results for the gross beta analysis were very similar for each monitoring station in the ERAMS program. Fluctuations that can be seen in the results presented in Figure 2 are largely attributable to natural phenomena (e.g., wind and rain) that influence the amount of particulates suspended in the air and, thereby, what is ultimately deposited on the filters.

As was noted in the data for the Perimeter Air Monitoring Program, the results for the ERAMS program were higher overall for the two stations immediately adjacent to the Y-12 Nuclear Security Complex (i.e., stations Y-12 East and Y-12 West). It is probable the higher results are associated with Y-12's campaign to modernize operational facilities and tear down unneeded buildings, but the exact cause is unknown.

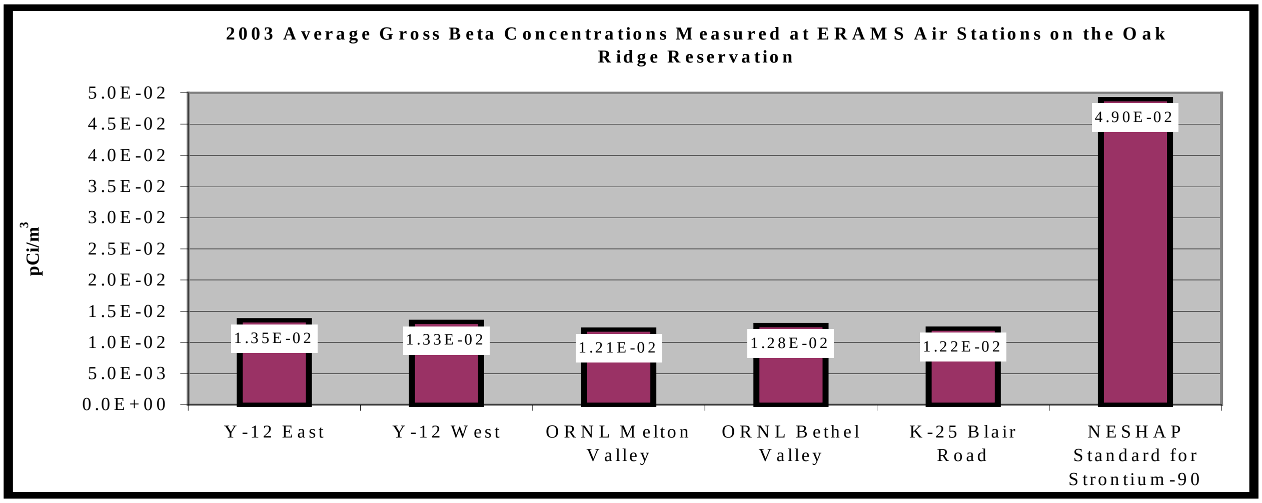



Note: Typical background values for gross beta range from 0.005 - 0.1 pCi/m$^3$ (ORISE, 1993)

**Figure 2: 2003 Gross Beta Results from Air Samples taken on the ORR in Association with EPA's Environmental Radiation Ambient Monitoring System**

The chart in Figure 3 depicts the 2003 average results for each station in the ORR ERAMS Program, along with the Clean Air Act (CAA) environmental limit for strontium-90. The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. The CAA specifies environmental concentrations for specific radionuclides that would be equivalent to this dose limit, but does not provide a standard for gross measurements. To evaluate the ERAMS data, staff compare the gross beta results reported for the program to the CAA limit for strontium-90, which has one of the most stringent standards of the beta emitting radionuclides. The standards apply to the dose above background, so the limit represented in Figure 3 has been adjusted to include the average gross beta measurement taken at the background station for the Fugitive Air Monitoring Program. It should be understood, strontium-90 is unlikely to be large contributor to the total beta measurements reported here and is used only as a reference point to determine if further analysis is justified.

As can be seen in Figure 3, the average results for the Y-12 East and Y-12 West monitoring stations are slightly higher than the remaining stations, but each of the ERAMS monitoring stations fall well below strontium-90 limit.




*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include the background measurements taken from the Division's Fugitive Air Monitoring Program during the same period.
** The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

**Figure 3: 2003 Average Gross Beta Results for Air Samples taken on the ORR in Association with EPA's Environmental Radiation Ambient Monitoring System**

## Conclusion

As in the past, the gross beta results for each of the five ERAMS air monitoring stations exhibited similar trends and concentrations. While slightly higher results were reported at monitoring locations near the Y-12 Nuclear Security Complex, the available ERAMS data for 2003 do not indicate a significant impact on the environment or public health from ORR emissions.

## References

Bechtel Jacobs Co. LLC, 2002. *Investigation Report of the Strontium Contamination Event at Oak Ridge National Laboratory, Oak Ridge, Tennessee*. BJC/OR-1172. September 13, 2002.

Oak Ridge Institute for Science and Education (ORISE). 1993. *Environmental Air Sampling.* Hand Out from Applied Health Physics Course (PWF: jb). June 8, 1993.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2001*. December 2000. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the State of Tennessee.* 2001. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency (EPA), 1988. *Environmental Radiation Ambient Monitoring System (ERAMS) Manual*. EPA 520/5-84-007, 008, 009. May 1988.

U.S. EPA. 1994. *Environmental Radiation Data Report 80*. EPA-402-R-97-004. February, 1997.

Yard, C.R., 2002. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

# CHAPTER 1 AIR QUALITY MONITORING

## Fugitive Radiological Air Emissions Monitoring (RMO)

Principal Authors: Gary Riner, Howard Crabtree

**Abstract**

The Tennessee Department of Environment and Conservation uses a portable high volume air sampler to monitor fugitive radiological air emissions at sites of interest on the Oak Ridge Reservation. A second high volume monitor has been placed at Fort Loudoun Dam in Loudon County to provide background data for comparison. Since August 1999, the portable unit has been stationed between the K-31 and K-33 Process Buildings at the East Tennessee Technology Park. Contaminated with various radionuclides, equipment in these two facilities is being removed and the buildings decontaminated. Initially near background levels, measurements taken at the site have trended upward since 2001. After DOE's contractor on the project was advised of rising results in 2002, the concentrations measured dropped to near background levels, but rose to the highest levels that had been measured in 2003. The contractor for the project subsequently assigned health physics personnel to review the State's data and provide a report of their findings. This report has not been received, but measurements at the site have returned to background levels. While the results were significantly above background, it does not appear standards specified in the Clean Air Act were exceeded.

**Introduction**

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division conducts monitoring for fugitive radiological air emissions on and in the vicinity of the Oak Ridge Reservation (ORR). This program uses a portable high volume air monitor to supplement air sampling performed at fixed locations. In addition to its mobility, the high volume monitor provides greater measurement sensitivity and resolution than can be achieved with the low volume monitors used in the division's Perimeter Air Monitoring Program.

From August 1999 through 2003, the portable sampler has been used to monitor emissions from the K-31 and K-33 Process Buildings (K31/33) at the East Tennessee Technology Park (ETTP). Together, these facilities cover more than 47 acres of land and contain greater than 150 acres of floor area. During operations, the facilities were an integral part of the uranium enrichment process and are known to be contaminated with uranium isotopes, technetium-99, and transuranic radionuclides. Both facilities are currently being cleaned up under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

**Methods and Materials**

Two high volume air samplers are used in this program. One of these units is mobile, allowing it to be moved to different locations of interest. The second unit has been stationed at Fort Loudoun Dam in Loudon County to collect background information. Both samplers use 8x10 glass fiber filters to collect suspended particulate matter as air is pulled through the units. The filters are collected weekly by staff and shipped by certified mail to the Tennessee Department of Public Health Radiochemistry Laboratory for analysis. Analysis includes gross alpha, gross beta, and gamma spectrometry on each of the weekly samples, with additional analysis performed where merited.

Monitoring in this program is directed toward locations where there is a potential for the release of fugitive/diffuse air emissions as a consequence of remedial or waste management activities. Results from the portable sampler are compared to background data collected by the monitor placed at Fort Loudoun Dam and environmental standards provided for radionuclides in 40CFR61 Appendix E Table 2 of the Clean Air Act (CAA).

**Results and Discussion**

As previously noted, the portable monitor has been stationed between the K-31 and K-33 Process Buildings at ETTP, since August 1999. These facilities, along with associated equipment, were contaminated during process operations and are currently being cleaned up in association with a CERCLA Action Memorandum issued in 1997 (DOE, 1997). The primary contaminants are uranium isotopes: although, technetium-99 and transuranic radionuclides are present due to the processing of spent nuclear fuel. While individual results have fluctuated over the years, a general trend can be observed in the data that has consistently risen from background levels to greater than five times the results reported at the background station. To illustrate this trend, Figure 1 depicts gross alpha data reported for the K31/33 facilities minus background measurements. Negative values in the chart represent instances where the background measurements exceeded the field measurements, which is not uncommon on the reservation (in the absence of man-made influences).

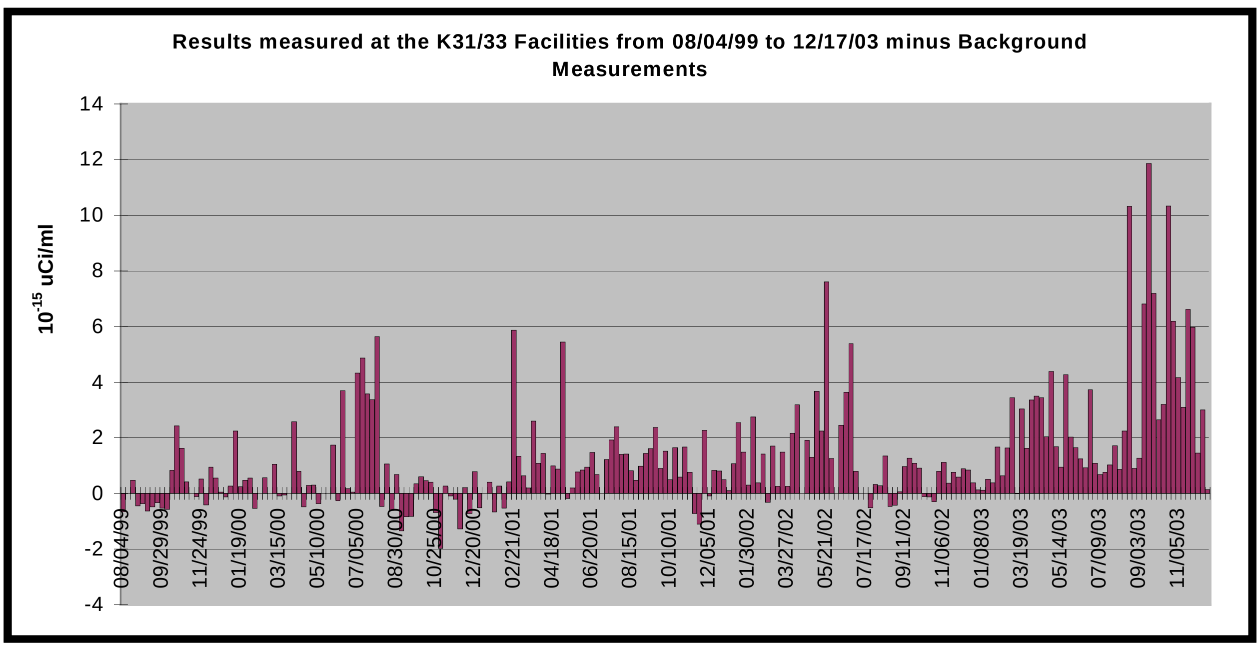



**Figure 1: Gross Alpha Activities reported for Monitoring performed at the K-31 and K-33 Process Buildings minus Background Concentrations (08/04/99 to 12/17/03)**

For this project, the results from the air sampler at the K-31/33 facilities were compared to background data to determine if releases were occurring. The data was then compared to the NESHAP environmental standards to assess if any releases identified were likely to have exceeded the exceeded the 10 mrem/year standard. In either case, both State and federal regulations require radioactive emissions to be as low as reasonably achievable (ALARA).

*K-31/33 Results vs. Background Data*

Figures 2 and 3 compare gross alpha and beta results from the K-31/33 facilities to background data taken at Fort Loudoun Dam during he same time period. As can be noted in the figures:

- Initial results from samples taken at the K-31/33 facilities were consistent with measurements and trends observed at the background station.
- In 2001, the alpha results increased slightly, but continued to follow the short-term trends seen in the background data.
- In the spring of 2002, the K-31/33 results diverged from the trends observed at the background station (i.e., the ETTP values increased, where background data decreased), indicating an increase of emissions from the ETTP Process Facilities or an additional contribution to the levels measured from a new and unknown source.
- In the winter of 2002, the results declined to near background levels after discussions on the data with DOE's contractor on the project. The elevated results were reported to be attributable to accelerated activities in the K-31 facility.
- In the spring of 2003, the results began to climb from background levels to the highest measurements reported at the site. In contrast to previous years, the gross beta measurements climbed significantly, along with the concentrations of gross alpha. After being notified of the escalating results, DOE and its contractors assigned health physics personnel to review the State's data and provide a report of their findings. While the division has not received this report, staff have been advised the elevated results were believed to be a consequence of work being performed in the K-31 Building near the division's monitor.
- In November and December 2003, the results at K-31/33 abruptly dropped. The decrease in the results suggested the cause of the elevated results was found and mitigated, but confirmation has not been received at this time.

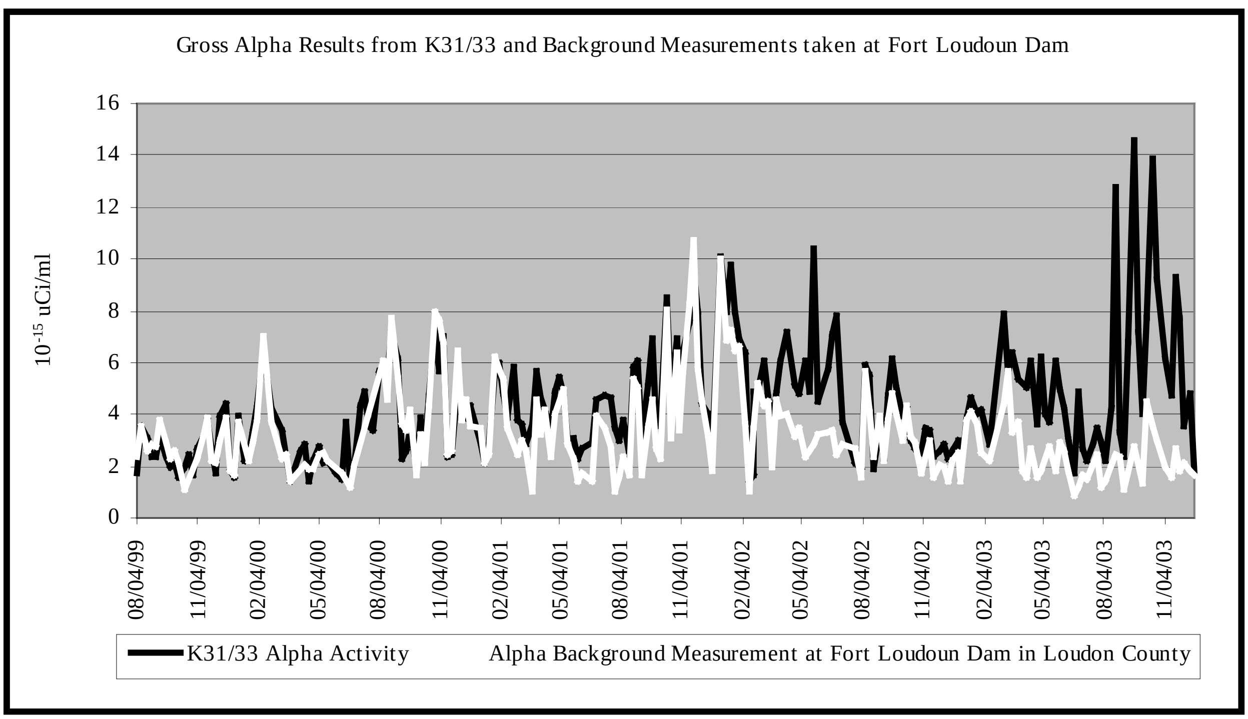



**Figure 2: Gross Alpha Results from Fugitive Air Monitoring performed at the K-31 and K-33 Facilities and the Background Station at Fort Loudoun Dam from 08/04/99 to 12/17/03**

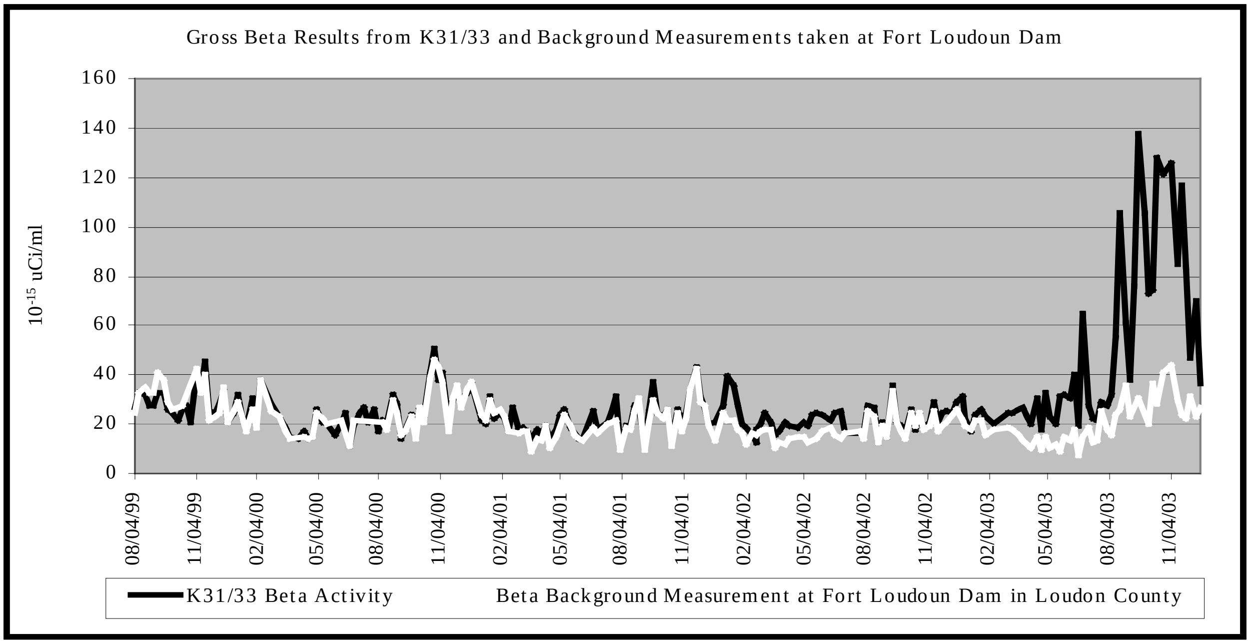


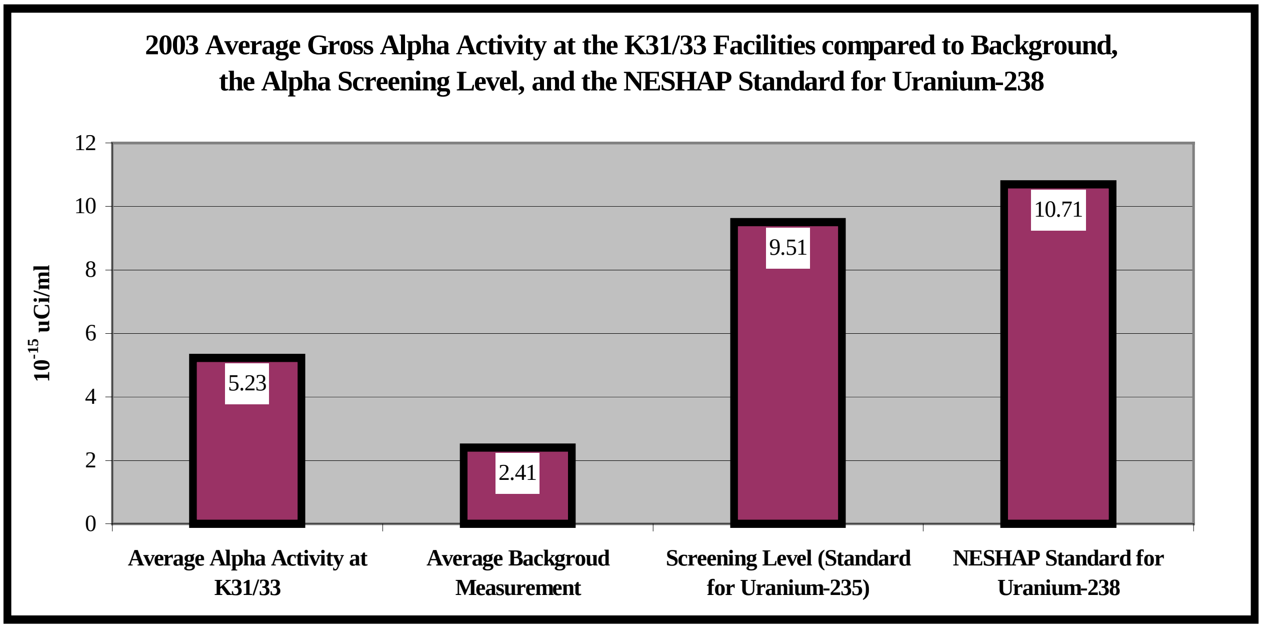

**Figure 3: Gross Beta Results from Fugitive Air Monitoring performed at the K-31 and K-33 facilities and the Background Station at Fort Loudoun Dam from 08/04/99 to 12/17/03**

*K-31/33 Results vs. NESHAP Standards*

The CAA specifies that exposures to the public from radioactive materials released to the air from DOE facilities shall not cause members of the public to receive an effective dose equivalent greater than 10 mrem in a year. Compliance with this standard is generally determined for point source emissions that employ air dispersion models to predict the dose at off-site locations. However, the CAA also provides environmental concentrations for radionuclides that can be used to demonstrate compliance with the 10mrem/year limit. TDEC staff use these standards to evaluate the predictions derived from the air dispersion models and to assess fugitive emissions.

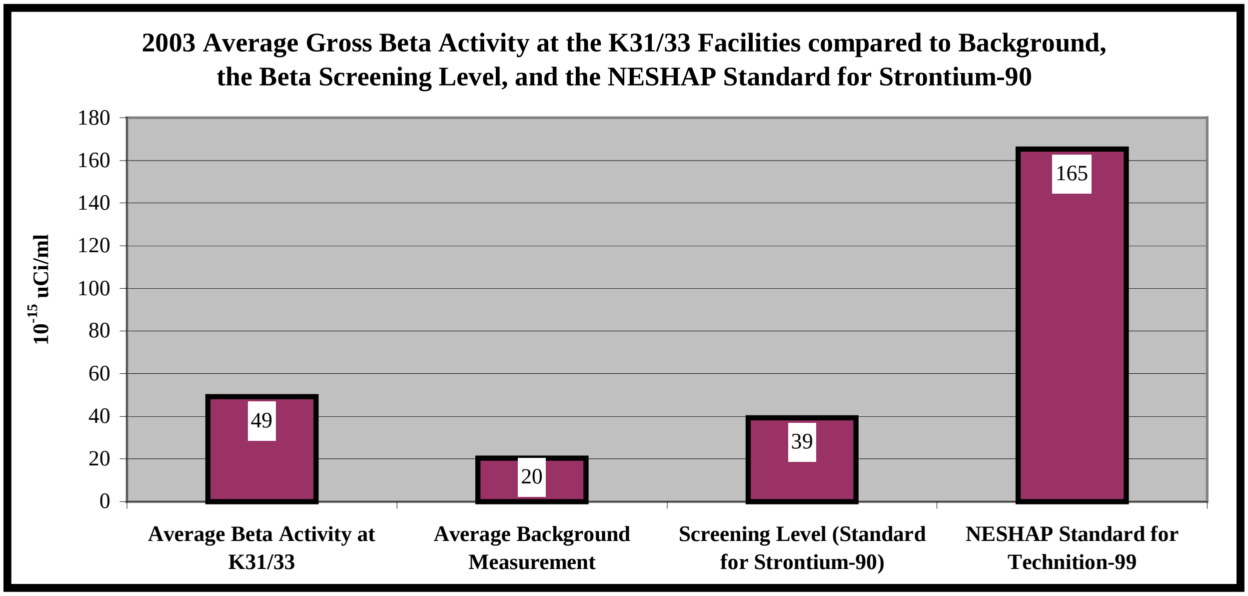
Because the hazards associated with the various radionuclides differ significantly, the CAA requires specific analysis for each isotope determined to be of concern. Consequently, the standards provided by the CAA do not include limits for gross alpha and beta activities. Nevertheless, the more economical gross measurements, when treated as surrogates for the more hazardous isotopes, provide an effective screening mechanism to determine if further evaluation is warranted. The standards used in the program to screen the data are those of uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter). Both have relatively restrictive limits and both are routinely encountered on the reservation.

The 2003 average gross alpha and beta activities at the K-31/33 facilities and the background station are provided in Figures 4 and 5. The predominant contributors to the gross results would be expected to be uranium-238 (from depleted uranium) and technetium-99 (a contaminant derived from recycling spent fuel). The NESHAP standards for both have been included in Figures 4 and 5. Since the environmental limits provided by the CAA apply to the dose above background, the standards depicted in the Figures 4 and 5 have been adjusted to include the average background measurement for the year.




*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.
**The CAA's Environmental Limit for uranium-235 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

**Figure 4: Average Gross Alpha measured at the K-31 and K-33 Process Buildings during 2003 compared to Background Measurements, the Alpha Screening Level, and the NESHAP Standard for Uranium-238**




*The standards provided by the Clean Air Act apply to the dose above background; therefore, the standards provided for reference in this figure have been adjusted to include background measurements taken during the same period.
** The CAA's Environmental Limit for strontium-90 is used as a screening mechanism and is provided here for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

**Figure 5: Average Gross Beta Measured at the K-31 and K-33 Process Buildings during 2003 compared to Background Measurements, the Beta Screening Level, and the NESHAP Standard for Technitium-99**

**Conclusion**

From 1999 through 2003, results from fugitive air monitoring at the K-31 and K-33 facilities rose from background levels to measurements five times the background levels. Individual results have fluctuated, but the data indicate an overall trend upward that has consistently increased since 2001. In 2003, DOE assigned Health Physics personnel to review the State's data and provide a report of their findings. Although the division has not received this report, staff have been advised the elevated results were believed to be a consequence of work being performed in the K-31 Building near the division's monitor. In November and December 2003, the results for the site dropped abruptly to background levels, suggesting the cause of the elevated data had been identified and mitigated. While the results for 2003 were above background levels, it does not appear standards specified in the Clean Air Act were exceeded.

**References**


Department of Energy (DOE), 1997. *Action Memorandum for Equipment Removal and Building Decontamination for Buildings K-29, K-31, and K-33 at the East Tennessee Technology Park.* DOE/OR/02-1646&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, Tennessee.

Department of Energy (DOE), 2003. *2003 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. DOE/ORO/01-2058&D1. Prepared for DOE by Science Applications International Corporation (SAIC). March 2003.

Environmental Protection Agency (EPA), 1994. *Clean Air Act*. 40 CFR Part 61, Subpart H. National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

National Council on Radiation Protection and Measurements (NCRP). 1985. *Environmental Radiation Measurements.* NCRP report No. 50. August 1, 1985.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the State of Tennessee*. 2001. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation (TDEC), 2003a. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan*. 2003. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2003b. *Tennessee Department of Environment and Conservation, DOE Oversight Division Environmental Monitoring Report January through December 2002.* Oak Ridge, Tennessee.

Yard, C.R., 2002. *Health, Safety, and Security Plan,* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, Oak Ridge, Tennessee.

# CHAPTER 1 AIR QUALITY MONITORING

## Oak Ridge Reservation Perimeter Ambient Air Monitoring Program (RMO)

Principal Authors: Howard Crabtree, James L. Dunlap

**Abstract**
The Tennessee Department of Environment and Conservation conducts a perimeter air monitoring program on the Oak Ridge Reservation using low volume air samplers. This program, in conjunction with associated air monitoring programs, provides information used to assess the impact of Department of Energy activities on the local environment and public health. In the program, samples are collected biweekly from twelve air monitors stationed near the boundaries of the reservation and at a background location (i.e., Fort Loudoun Dam). Each sample is analyzed for gross alpha and gross beta radiation at the state radiochemistry laboratory. A composite sample from each location is analyzed annually for gamma emitters. Results from the perimeter monitoring stations are compared to the background measurements and environmental standards provided in the Clean Air Act. While the results for 2003 were slightly higher for the monitors stationed at the Y-12 National Security Complex, data from the program did not indicate a significant impact on local air quality from activities on the reservation.

**Introduction**
The Tennessee Department of Environment and Conservation (TDEC), Department of Energy Oversight Division provides radiochemical analysis of air samples taken from twelve low volume air monitors located on and in the vicinity of the Oak Ridge Reservation (ORR). The monitors used to collect the samples are owned by DOE and maintained by DOE contractors. Data derived from this program, along with information generated by the other air monitoring programs on the reservation, are used to:

- Assess the impact of DOE activities on the public health and environment,
- Identify and characterize unplanned releases,
- Establish trends in air quality, and
- Verify data generated by DOE and its contractors

**Methods and Materials**
The twelve air monitors used in the program are owned by DOE and DOE contractors are responsible for their maintenance and calibration. Nine of the units are a component of DOE's ORR perimeter air monitoring system. The remaining three monitors were previously used by the Y-12 complex in their perimeter air monitoring program.

Each of the monitors use forty-seven millimeter borosilicate glass fiber filters to collect particulates as air is pulled through the units. The ORR perimeter monitors employ a pump and flow controller to maintain airflow through the filters at approximately two standard cubic feet per minute. The Y-12 monitors use a pump and rotometer and are set to average approximately two standard cubic feet per minute.

Air filters from the monitors are collected biweekly and sent by certified mail to the state's radiochemical laboratory in Nashville, Tennessee, for analysis. Analysis includes gross alpha and gross beta on the biweekly samples. Gamma spectrometry is performed on samples that exhibit elevated gross results and annually on composite samples.

The twelve air monitoring stations used in the program are listed in Table 1. Eleven of these stations are located around the perimeter of the ORR and Y-12 facility (Figure 1). The twelfth site is the background station located near Fort Loudoun Dam in Loudon County.

**Table 1: Perimeter Air Monitoring Stations**

| Station | Location | County |
|---|---|---|
| 4 | Y-12 Perimeter near portal 2 | Anderson |
| 5 | Y-12 Perimeter near Building 9212 | Anderson |
| 8 | Y-12 Perimeter west end near portal 17 | Anderson |
| 35 | East Tennessee Technology Park | Roane |
| 37 | Bear Creek at Y-12 / Pine Ridge | Roane |
| 38 | Westwood Community | Roane |
| 39 | Cesium Fields at Oak Ridge National Laboratory | Roane |
| 40 | Y-12 East | Anderson |
| 42 | East Tennessee Technology Park off Blair Road | Roane |
| 46 | Scarboro Community | Anderson |
| 48 | Deer Check Station on Bethel Valley Road | Anderson |
| 52 | Fort Loudoun Dam (Background Station) | Loudon |

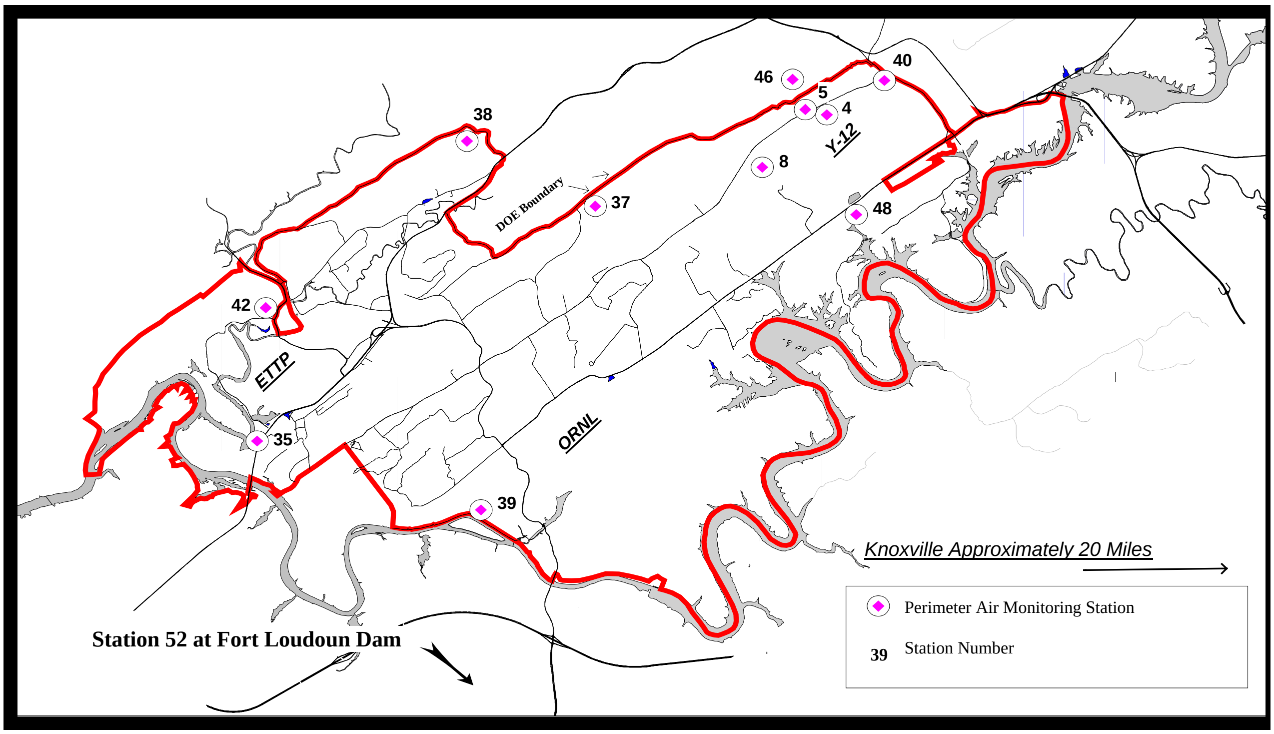



**Figure 1: Approximate Location of Perimeter Air Monitoring Stations**

## Results and Discussion

In general, results reported in 2003 for the perimeter air monitoring stations were near those reported for the background station. Similar trends in the activities for gross alpha and gross beta were observed for each monitoring station. Figures 2 and 3 illustrate the correlation between fluctuations in the gross alpha and beta results at the perimeter stations and the background location. These fluctuations, to a large degree, can be attributed to natural phenomena or changing environmental conditions, which increase or decrease the amount of particulate deposited on the sampling filters. For example, concentrations of potassium-40 and radionuclides in the uranium and thorium decay series may increase, because soils in which they naturally occur have been dispersed in the air as a consequence of dry conditions, heavy winds, and/or local activities (e.g., construction). Conversely, rain and snow can remove materials suspended in the air reducing the concentration of contaminants deposited on the air filters. Concentrations of cosmogenic radionuclides (e.g., beryllium-7) are also highly variable, fluctuating in response to sunspot activity and the degree of mixing between the stratosphere, where they are produced, and the troposphere, where the samples are colleted (ORISE, 1993).

Slightly elevated results (compared to background values) can be noted in Figures 2 and 3 during January and February for monitoring locations at the Y-12 National Nuclear Security Complex (stations 4, 5, and 8). Similar excursions were noted in 2002, but the exact cause of the elevated results remains unknown. It is believed the current campaign at Y-12 to modernize operational facilities and tear down unneeded buildings may have caused the slightly elevated results. As discussed below, the short-term excursion does not constitute a violation of applicable standards.

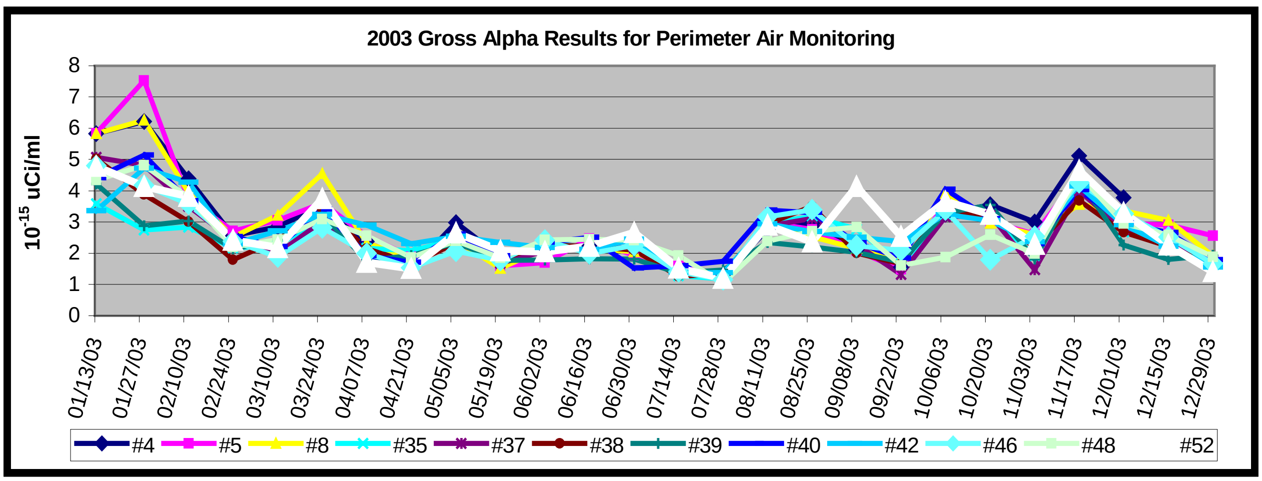



**Figure 2: 2003 Gross Alpha Results for TDEC Perimeter Air Monitoring Stations on the ORR**

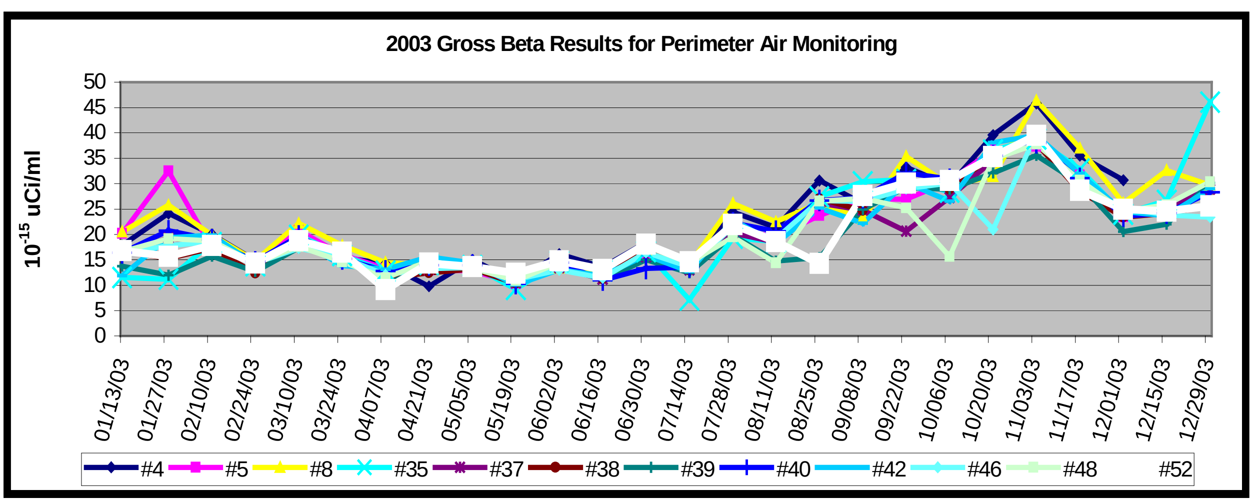
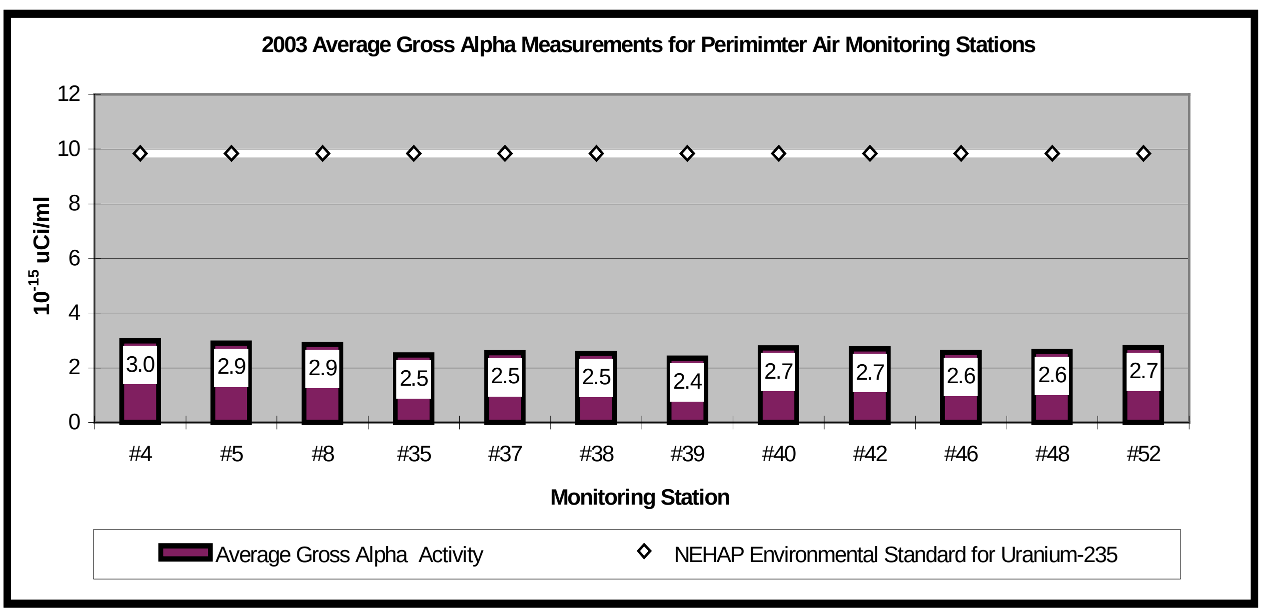



**Figure 3: 2003 Gross Beta Results for TDEC Perimeter Air Monitoring Stations on the ORR**

The simplest method of assessing the impact of ORR air emissions on the local environment is to compare results from the perimeter monitoring stations to those of the background station located at Fort Loudoun Dam (Station 52). As can be seen in Figures 2 through 5, the activities reported for the perimeter air monitoring stations for gross alpha and gross beta were relatively consistent with the background values, with the exceptions previously noted at the Y-12 National Nuclear Security Complex.

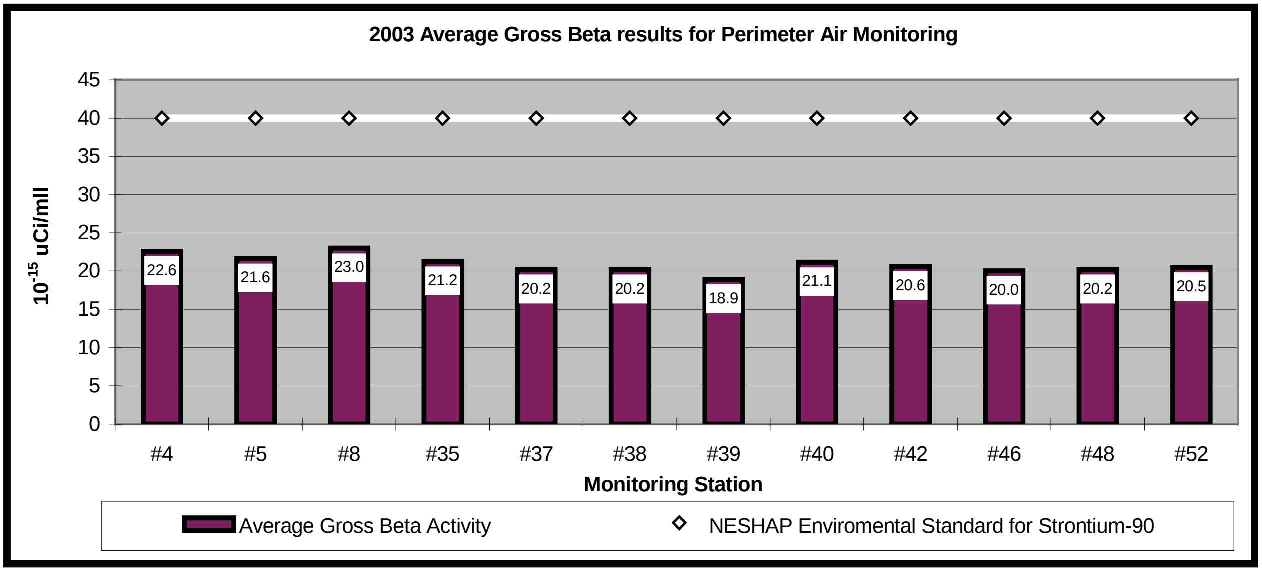
The Clean Air Act (CAA) specifies that exposures to the public from radioactive materials released to the atmosphere from DOE facilities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem above background measurements. Data from TDEC's air monitoring is compared to ambient air concentrations provided in the CAA for demonstrating compliance with the 10mrem/year limit. While the CAA environmental standards do not include limits for gross alpha and beta, these measurements provide an effective tool to assess if further analysis is merited.

Figures 4 and 5 show the average activity for gross alpha and beta measured during the year 2003 at the perimeter air stations. The CAA environmental standards (adjusted to include background radiation) for uranium-235 (primarily an alpha emitter) and strontium-90 (a beta emitter) are provided for comparison. These isotopes have some of the more restrictive standards prescribed by the CAA. It should be understood that it is very unlikely that these isotopes would be responsible for a major proportion of the gross activity reported for the samples.




*The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurements.
**The CAA's Environmental Limit for uranium-235 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

**Figure 4: 2003 Average Gross Alpha Results for TDEC Perimeter Air Monitoring Stations on the ORR**




*****The standards provided by the Clean Air Act apply to the dose above background: therefore, the standard provided for reference in the figure has been adjusted to include the background measurement.

**The CAA's Environmental Limit for strontium-90 is provided for comparison. It is unlikely the isotope contributes a major proportion of the gross activity reported for the samples.

**Figure 5: 2003 Average Gross Beta Results for TDEC Perimeter Air Monitoring Stations on the ORR**

The annual gamma analysis performed on composite samples from each station has not been completed; consequently, these results were not available for this report. In the past, the gamma results have been considered consistent with background measurements.

## Conclusion

Environmental concentrations of radionuclides in the atmosphere tend to vary from location to location and seasonally in response to natural and anthropogenic influences. In this regard, results of radiochemical analysis of samples taken at ORR perimeter air monitoring stations appear to follow similar trends as the background station located near Fort Loudoun Dam. In general, concentrations of radionuclides reported for the perimeter air monitoring stations were consistent with data reported for the background stations. Short term excursions above background measurements were observed in data for air monitors in the vicinity of the Y-12 facility. While the exact cause of these excursions is unknown, the data did not indicate exceedances of standards provided in the CAA.

## References

Environmental Protection Agency (EPA) 1994. *Clean Air Act.* 40 CFR Part 61, Subpart H. National Emissions Standards for Hazardous Air Pollutants (NESHAPS).

National Council on Radiation Protection and Measurements (NCRP), 1985. *Environmental Radiation Measurements.* NCRP report No. 50. August 1, 1985.

Oak Ridge Institute for Science and Education (ORISE), 1993. *Environmental Air Sampling.* Hand Out from Applied Health Physics Course (PWF:jb). June 8, 1993.

Tennessee Department of Environment and Conservation, 2002. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan*. 2002. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the Department of Energy and the State of Tennessee*. 2001. Oak Ridge, Tennessee.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

# CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

## Fish Tissue Monitoring

Principal Author: Roger Petrie


**Abstract**

The Tennessee Valley Authority (TVA) conducts an annual Community Assessment Project to evaluate the condition of the reservoirs in the Tennessee River Valley. The DOE Oversight Division acquired largemouth bass from TVA at four locations around the ORR during the annual Community Assessment Project in order to compare results with those from other agencies and organizations. Tissue samples from these fish were then analyzed for contaminants of concern. Results indicate that there are no contaminants present in the largemouth bass tissue that pose a threat to human health.


**Introduction**

The Tennessee Department of Environment and Conservation posts warning signs on streams or lakes in which public health is endangered. In Tennessee, the most common reasons for a river or lake to be posted are the presence of sewage bacteria or other contaminants in the water, sediment, or fish of a waterbody.

When fish tissue samples show levels of a contaminant higher than established criteria, the waterbody is posted and the public is advised of the danger. If needed, TWRA can enforce a fishing ban. Approximately 84,100 lake acres and 142 river miles across the state are currently posted due to contaminated fish. When the department issues new advisories, signs are placed at significant public access points and a press release is submitted to local newspapers.

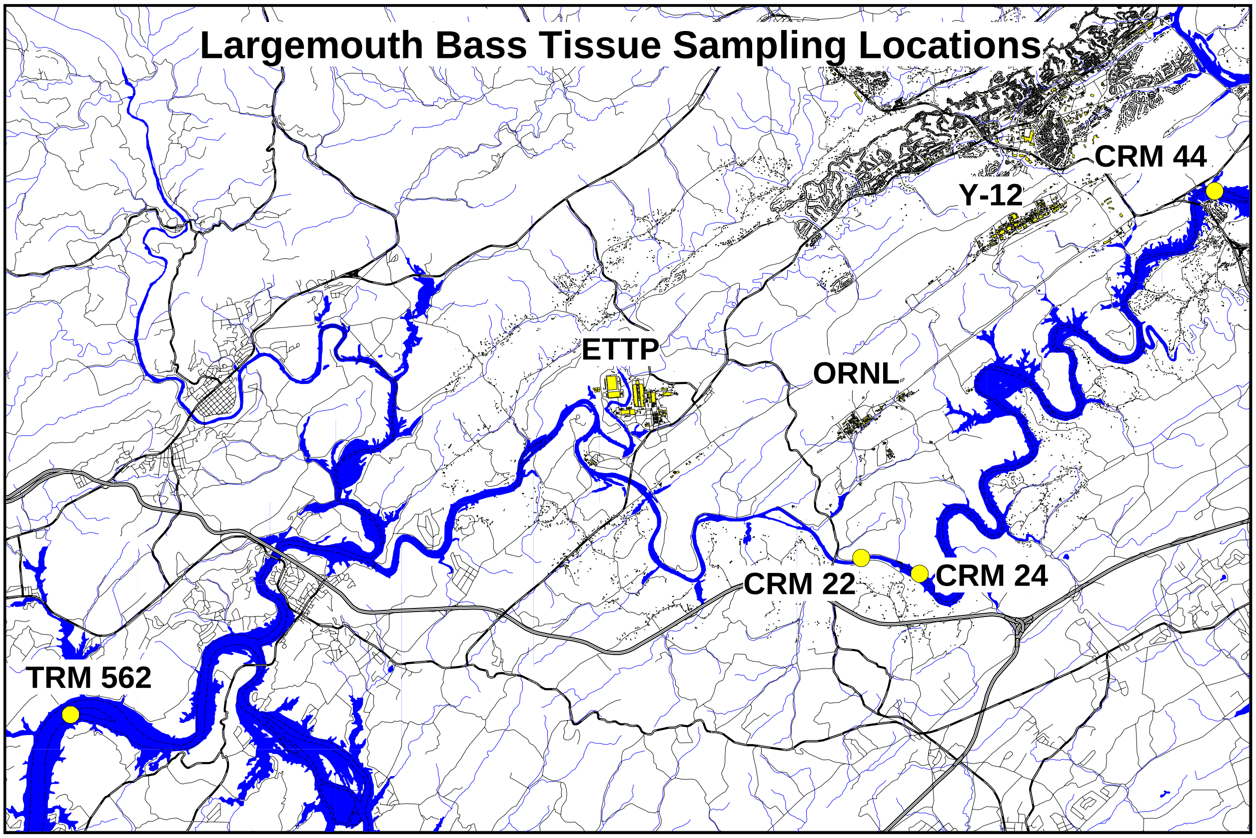
The State of Tennessee posts two types of advisories. A public fishing advisory will be considered when the calculated risk of additional cancers $10^{-4}$ for typical consumers $10^{-5}$ for atypical consumers. A "do not consume" advisory will be issued for the protection of typical consumers and a "precautionary advisory" will be issued for the protection of atypical consumers.

The Tennessee Valley Authority (TVA) conducts an annual Community Assessment Project to evaluate the condition of the reservoirs in the Tennessee River Valley. The DOE Oversight Division acquired five largemouth bass from TVA at each of four locations (Table 1 and Figure 1) around the ORR during the annual Community Assessment Project in order to compare results with those from other agencies and organizations. Tissue samples from these fish were then analyzed for contaminants of concern.

**Table 1. Fish Tissue Sampling Locations**

| Station | Site |
|---|---|
| Watts Bar Transition | TRM 562 |
| Watts Bar Inflow | CRM 22 |
| Melton Hill Forebay | CRM 24 |
| Melton Hill Transition | CRM 44 |

**Figure 1. Fish Tissue Sampling Locations**




## Methods and Materials

Lengths and weights were obtained for each fish. Fillets were then removed from each fish and homogenized. A five-fish tissue composite from each of four locations was analyzed for mercury, arsenic, PCBs, gross alpha, gross beta, and gamma radionuclides. Evaluation of the arsenic and PCB results includes the calculation of an R value. The R value is the plausible upper limit risk of cancer as calculated from the formula shown in Figure 2. This formula is taken from TDEC Rule 1200-4-3-.03. If the calculated R value is greater than 0.0001 (1E-4) then a "Do not consume" advisory may be considered. If the calculated R value is greater than 0.00001 (1E-5) then a "Precautionary" advisory may be considered. The "Precautionary" advisory is to protect atypical consumers. Atypical consumers are, as defined in TDEC Rule 1200-4-3-.03, those persons in the vicinity of a stream or lake who due to physiological factors or previous exposure are more sensitive to specific pollutants than is the population in general. Examples of atypical consumers may include, but are not limited to: children; pregnant or nursing women; subsistence fishermen; frequent purchasers of commercially harvested fish; and agricultural, industrial, or military personnel who may have had previous occupational exposure to the contaminant of concern. Typical consumers are considered to be all other persons.

**Figure 2. Calculation of the Risk of Additional Cancers**

$$R = q \times \frac{(C \times I \times X)}{W}$$

Where:
R = Plausible upper limit risk of cancer
q = Carcinogenic Potency Factor
C = Concentration of chemical in the edible portion of the species
I = Mean daily consumption (0.0065 kg/day)
X = Relative absorption coefficient (usually 1 unless otherwise noted)
W = Average human mass (75 kg)

## Results and Discussion

The results of the mercury analysis (Table 2) show that there were no levels above any of the regulatory levels.

**Table 2. Hg Levels in Fish Tissue Samples**

| Site | Hg (ppm) |
|---|---|
| TRM 562 | 0.05 |
| CRM 22 | 0.07 |
| CRM 22 (Duplicate) | 0.05 |
| CRM 24 | 0.03 |
| CRM 44 | 0.1 |

FDA Action Level = 1.0 ppm
EPA Water Quality Criteria = 0.3 ppm
State of Tennessee Guideline = 0.5 ppm

The results of the arsenic analysis are shown in Table 3. Currently, there are no regulatory levels for arsenic in fish tissue. The FDA has guidelines for arsenic in crustacea (76 ppm) and molluscan bivalves (86 ppm), but none for fish tissue. A risk analysis was conducted, as per TDEC Rule 1200-4-3-.03, and the results are shown in Table 3. None of the calculated R values exceed the 10-4 level used to post fish advisories for typical consumers. Following FDA guidelines for arsenic in fish tissue, the calculations were based on 10% of the reported arsenic concentrations. A calculated value for arsenic is shown in Table 3, based on the additional cancer risk formula, to show what levels of arsenic would need to present to warrant a possible fish advisory posting.

**Table 3. Arsenic Levels in Fish Tissue Samples**

| Site | As (ppm) | As[1] | R | C (1E-4)[2] | C (1E-5)[3] |
|---|---|---|---|---|---|
| TRM 562 | 0.2 | 0.02 | 0.000026 | 0.769 | 0.077 |
| CRM 22 | 0.1 | 0.01 | 0.000013 | 0.769 | 0.077 |
| CRM 22 (Duplicate) | 0.1 | 0.01 | 0.000013 | 0.769 | 0.077 |
| CRM 24 | 0.3 | 0.03 | 0.000039 | 0.769 | 0.077 |
| CRM 44 | 0.2 | 0.02 | 0.000026 | 0.769 | 0.077 |

[1] – This assumes 10% of total arsenic is inorganic (as per FDA guidelines)
[2] – C (1E-4) = State Of Tennessee “Do not consume” advisory
[3] – C (1E-5) = State Of Tennessee “Precautionary” advisory

The results of the PCB analysis (Table 4) show that there were no levels above any of the regulatory levels. A risk analysis was conducted, as per TDEC Rule 1200-4-3-.03, and the results are shown in Table 4. None of the calculated R values exceed the 10-4 level used to post precautionary fish advisories for typical consumers. The calculated R values do indicate that a precautionary advisory for atypical consumers may be warranted. A calculated value for PCBs is shown in Table 4, based on the additional cancer risk formula, to show what levels of PCBs would need to present to warrant a possible fish advisory posting.

**Table 4. PCB Levels in Fish Tissue Samples**

| Site | PCB (ppm) | R | C (1E-4)[1] | C (1E-5)[2] |
|---|---|---|---|---|
| TRM 562 | U | 0 | 0.577 | 0.058 |
| CRM 22 | 0.0787 | 0.0000136 | 0.577 | 0.058 |
| CRM 22 (Duplicate) | 0.354 | 0.0000613 | 0.577 | 0.058 |
| CRM 24 | 0.114 | 0.0000197 | 0.577 | 0.058 |
| CRM 44 | 0.114 | 0.0000197 | 0.577 | 0.058 |

FDA Action Level = 2.0 ppm
[1] – C (1E-4) = State Of Tennessee "Do not consume" advisory
[2] – C (1E-5) = State Of Tennessee "Precautionary" advisory

The results of the gross alpha and gross beta analysis are shown in Table 5. Currently, the State of Tennessee has no regulatory levels for gross alpha or gross beta. As can be seen in the results, the locations above the ORR actually had levels equivalent to the locations below the ORR.

**Table 5. Gross Alpha and Gross Beta in Fish Tissue Samples**

| Site | Gross Alpha | Gross Beta |
|---|---|---|
| TRM 562 | 0.071 ± 0.059 pCi/g | 6.55 ± 0.10 pCi/g |
| CRM 22 | 0.075 ± 0.057 pCi/g | 6.42 ± 0.10 pCi/g |
| CRM 24 | 0.077 ± 0.054 pCi/g | 5.952 ± 0.093 pCi/g |
| CRM 24 (Duplicate) | 0.077 ± 0.054 pCi/g | 5.872 ± 0.093 pCi/g |
| CRM 44 | 0.092 ± 0.066 pCi/g | 6.81 ± 0.11 pCi/g |
| CRM 44 (Duplicate) | 0.096 ± 0.069 pCi/g | 7.55 ± 0.12 pCi/g |

The results of the gamma radionuclide scan are shown in Table 6. Currently, the State of Tennessee has no regulatory levels for gamma radionuclides in fish tissue. The results show the presence of K-40, Pb-214, and Bi-214. All of these radionuclides are naturally occurring. The presence of Cs-137 is due to the input of this contaminant from White Oak Creek. Using DOE PRG's for recreation, a risk analysis was conducted. The calculations indicate that the level present in the sample is below the 10-4 risk for additional cancers. If DOE parameters for risk analysis are used then the levels of Cs-137 do pose a risk at the 10-6 level. If State of Tennessee parameters are used though, the levels of Cs-137 do not pose a risk at the 10-6 level.

**Table 6. Gamma Radionuclide Levels in Fish Tissue Samples**

| Site | K-40 | Pb-214 | Bi-214 | Cs-137 |
|---|---|---|---|---|
| TRM 562 | 3.58 ± 0.059 pCi/g | | | |
| CRM 22 | 3.74 ± 0.31 pCi/g | 0.095 ± 0.023 pCi/g | 0.127 ± 0.028 pCi/g | 0.177 ± 0.018 pCi/g |
| CRM 24 | 3.55 ± 0.28 pCi/g | | | |
| CRM 44 | 4.02 ± 0.29 pCi/g | | | |
| CRM 44 (Duplicate) | 4.07 ± 0.29 pCi/g | | 0.102 ± 0.024 pCi/g | |

## Conclusion

Based on the results, there is no apparent risk to human health resulting from the contaminants that were analyzed. The levels of PCBs in the fish tissue are comparable to historical values from other locations in the area. These values would indicate that a precautionary advisory for atypical consumers might be warranted. Further sampling would be required to confirm this conclusion. The levels of mercury were also comparable to historical values from the same locations. It is important to note that comparison of these results to the commonly acquired values for channel catfish is not necessarily valid. The differences in species and behaviors can cause wide variations in results for these two species.

## References

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 1999. *Rules Of the Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control. Chapter 1200-4-3. General Water Quality Criteria.* State of Tennessee.

U.S. Environmental Protection Agency. 2000. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1: Fish Sampling and Analysis. Third Edition.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 823-B-00-007.

Yard, C. R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

## Canada Geese Monitoring

Principal Author: Roger Petrie

**Abstract**

On June 24 and 25, 2003, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted oversight of the annual Canada Geese (*Branta canadensis*) monitoring project on the Oak Ridge Reservation (ORR). The objective of this study was to determine if geese are becoming contaminated on the ORR. The captured geese were transported to the Tennessee Wildlife Resources Association (TWRA) game check station on Bethel Valley Road and tested for radioactive contamination. None of the geese captured at this year showed elevated gamma counts above the 5pCi/g game release level. Since no contaminated geese were captured, the DOE-Oversight Division did not conduct additional offsite sampling of Canada Geese.

**Introduction**

A large population of Canada geese, both resident and transient, frequents the Oak Ridge Reservation (ORR) (Crabtree 1998). The thriving goose population in this area makes this animal an easily accessible food for area residents. Geese with elevated levels of Cs137 in muscle tissue have been found on the ORR (MMES 1987 and Loar 1994). Studies in the 1980s demonstrated that geese associated with the contaminated ponds/lakes on the ORR can accumulate radioactive contaminants quickly and that contaminated geese frequent off site locations (Loar 1990, Waters 1990, MMES 1987).

Every year the Department of Energy (DOE) and Tennessee Wildlife Resource Agency (TWRA) capture geese on the ORR during the annual "Goose Roundup" and perform whole body counts on them to determine if the birds are radioactively contaminated. During the 1998 "Goose Roundup," 38 geese at ORNL contained Cesium 137 concentrations that exceeded the game release limit of 5 pCi/g (ORNL 1998). A subsequent study in September 1998 found elevated levels of Cs137 in grass and sediment at two reaches of White Oak Creek south of 3513 Pond and in grass around the 3524 pond (ORNL 1998). In 2002, three young-of-the-year geese from the west end of ORNL were found to have Cesium 137 levels above the game release level.

The division has a sampling plan that is implemented when geese with elevated gamma readings are detected during the regular "Goose Roundup." If any geese with elevated gamma readings are detected, then arrangements are made to sample geese that are found in the vicinity of the ORR on non-DOE property. This is to determine if contaminated geese are leaving the reservation and are presenting a risk to area hunters.

**Results and Discussion**

During the 2003 sampling, a total of 202 birds were captured. Most of the adult geese were banded and all were released. A subsample of twenty birds from each site were given total body counts for five minutes with a sodium iodide detector at the TWRA game checking facility on Bethel Valley Road. None of the birds analyzed had levels of gamma above the 5pCi/g game release level. In fact, none of the analyzed birds had levels of Cesium 137 above 1 pCi/g. Table 1 shows results of the 2003 DOE Goose Roundup.

**Table 1. 2003 DOE Goose Round-up Results**

| Site | Date | # Captured | Adults | Juveniles | # > 5pCi/g |
|---|---|---|---|---|---|
| ETTP (K-1007 Area) | 6/24 | 30 | 30 | 0 | 0 |
| ORNL (STP Area) | 6/24 | 21 | 21 | 0 | 0 |
| ORNL (1505 Area) | 6/24 | 37 | 16 | 21 | 0 |
| Clark Center Park | 6/25 | 47 | 26 | 21 | 0 |
| OR Marina | 6/25 | 67 | 47 | 20 | 0 |
| **Totals** | | 202 | 140 | 62 | 0 |

Since none of the birds analyzed showed signs of contamination, no additional offsite sampling was conducted.

**Conclusion**

Although none of the birds analyzed showed signs of contamination, historical information indicates that this species is still susceptible to contamination from sources on the ORR. It does, however, indicate that there is a reduced likelihood of this situation existing.

**References**


Ashwood, T.L. ed. 1993. *Seventh Annual Report on the ORNL Biological Monitoring and Abatement Program*, Environmental Sciences Division Publication No. 4074. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Blaylock B. G., M.L. Frank, F.O. Hoffman, L.A. Hook, G.W. Suter, J. A. Watts. 1992. *Screening of Contaminants in Waste Area Grouping 2 at Oak Ridge National Laboratory*, Oak Ridge, Tennessee. ORNL/ER-62/R1, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Crabtree, H., TDEC DOE-Oversight, 1998. Personal communication.

Evans, J., TWRA, Personal communication.

Loar, J. M., ed. 1990, *Fourth Annual Report on the ORNL Biological Monitoring and Abatement Program*, ORNL/TM- (Draft). Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Loar, J. M., ed. 1994. *Fourth Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River*, ORNL/TM-11544. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

MMES 1987, *Environmental Surveillance of the U.S. Department of Energy Oak Ridge Reservation and Surrounding Environs During 1986*, Volume 2: Data Presentation, ES/ESH-1/V2,

ORNL 1994, *Third Report on the Oak Ridge National Laboratory Biological Monitoring and Abatement Program for White Oak Creek Watershed and the Clinch River*. ORNL/TM-11358, Environmental Sciences Division Publication No. 4255.

ORNL 1998. Study Plan and Analysis Results from Contamination Study on Soils and Vegetation Around 3524 and 3513 Ponds, First Creek and White Oak Creek.

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee. 2001.

Waters, A. E. 1990. *Radioactive and Non-radioactive Contaminants in Migratory and Resident Waterfowl Inhabiting the Oak Ridge Reservation*, East Tennessee, Master of Science Degree Thesis.The University of Tennessee, Knoxville, Tennessee.

Yard, C. R. 2002. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 2 BIOLOGICAL/FISH AND WILDLIFE

## Rapid Bioassessment III: Benthic Macroinvertebrate Biomonitoring in Streams on the Oak Ridge Reservation

Principal Author: Randall P. Hoffmeister

**Abstract**

Semi-quantitative benthic macroinvertebrate samples were collected from study sites on five streams impacted by Department of Energy (DOE) operations. Using the State of Tennessee standard operating procedures for macroinvertebrate surveys, samples were collected, processed, and analyzed using applicable metrics. A score was calculated from the metrics and a stream site health rating was assigned. In general, results showed signs of biotic improvement with increasing water quality downstream of DOE influences. Only two study sites had a stream rating as healthy as Bioregion reference conditions. Continued benthic macroinvertebrate monitoring would more closely define impacts on the aquatic environment from DOE related activities. Assessments of DOE remedial activities and cleanup efforts can also be made from generated data.

**Introduction**

Benthic macroinvertebrates are organisms that inhabit the bottom substrates of aquatic systems. Examples include insects, crustaceans, annelids, and mollusks. Because of their relatively long life spans and sedentary nature, benthic macroinvertebrate community structure can be useful in assessing the condition or health of an aquatic system. A continuous biomonitoring program is a proven method of assessing and documenting any changes that may occur within the impacted system.

Benthic macroinvertebrate and surface water samples were collected from locations on five streams originating on the ORR that have been impacted by past and present DOE operations. Two of these streams, East Fork Poplar Creek and Bear Creek, have been impacted by the Y-12 Plant. One stream, Mitchell Branch, has been impacted by the East Tennessee Technology Park (ETTP) and two streams, White Oak Creek and Melton Branch, have been impacted by operations at the Oak Ridge National Laboratory (ORNL). The objective of this study was to assess and document the health of ORR streams compared to ideal reference conditions.

**Method and Materials**

Semi-quantitative sampling of benthic macroinvertebrate communities was conducted during the period of April 22, 2003, to May 1, 2003, using the RBP III method described in the State of Tennessee Department of Environment and Conservation Division of Water Pollution Control *Quality System Standard Operating Procedure* (SOP) *for Macroinvertebrate Stream Surveys.* Depending on stream size, either a one square meter kick net (larger streams) or a D-frame stationary net (smaller streams) was used to collect benthic macroinvertebrates. In larger streams, two separate riffle kicks were performed by a two-person crew. One individual held the double handle kick net perpendicular to the current with the net's weighted bottom resting firmly on the streambed. Another person disrupted the substrate with a kicking and sweeping motion in a one square meter stretch just upstream of the net. Benthic organisms were dislodged and drifted into the waiting net. After allowing suitable time for all the debris to flow into the net, the person performing the kick lifted the bottom of the net at each end in a smooth, continuous motion while the person holding the net at the top was careful not to let the top edge dip below the water's surface. After a second riffle was sampled in an identical fashion, the collected organisms were picked from the net and transferred into a container as a composite sample.

At smaller stream sites (e.g., Bear Creek BCK 12.3), where riffles were less than one meter wide, four separate riffle kicks were performed using the one-man, D-frame net. A crewmember held the single handle net perpendicular to the current with the net's bottom pressed firmly to the streambed. The same person disrupted the upstream substrate for an 18-inch distance and the width of the net, dislodging any benthic organisms. After allowing suitable time for all debris to drift into the net, the net was lifted from the water and three additional riffles were sampled in the same fashion. The debris from all four kicks was composited.

Benthic macroinvertebrate samples were preserved in 80% ethanol with internal and external site specific labels. Labeling information included site name, sampling date, and sampler's initials. If more than one sample container was needed at a site, the debris was split evenly with internal and external labels completed for each container.

Sample collection methods were modified in the White Oak Creek watershed due to the presence of radioactive contamination in the stream sediments. The two, 1-meter kick samples were combined in a 5-gallon bucket, creek water was added and the sample swirled to suspend the lighter material (including invertebrates) with the elutriate then being poured through a sieve. This process was repeated five times to ensure the thorough collection of organisms. Any material not needed was returned to the creek. Samples from radioactively contaminated sites were processed in laboratory space designated by ORNL Health Physics personnel.

Once sampling was completed at all sites the sample containers were transported to the State Biology Laboratory in Nashville for processing. Following the State SOP for laboratory sample processing, all samples were sorted and benthic macroinvertebrates were identified and enumerated to the genus level. Using raw benthic data biological metrics were calculated in order to develop an overall site rating. Calculated metrics included Taxa Richness, EPT (Ephemeroptera, Plecoptera, Trichoptera) Richness, Percent EPT, Percent OC (oligochaetes and chironomids), NCBI (North Carolina Biotic Index), Percent Dominant Taxon, and Percent Clingers. Once values were obtained for the seven metrics, a score of 0, 2, 4, or 6 was given to each metric based on comparison to the metric target values for Bioregion 67F, the reference ecoregion for Oak Ridge Reservation streams. The seven scores were totaled and the overall index score was compared to the Target Index Score (TIS) for Bioregion 67F, TIS=32. The biological condition rating of the sampling site was estimated within a range of Severely Impaired and Non-Supporting (index score < 10) to Non-Impaired and Fully Supporting (index score>=32). A description of the metrics and the equations used to calculate them can be obtained by referencing the state SOP. The biometrics used to generate stream ratings and the expected response of each metric to stress introduced to the system are presented in Table 1.

**Table 1. Description of Metrics and Expected Responses to Stress**

| Category | Metric | Description | Response to Stress |
|---|---|---|---|
| Richness Metrics | Number of taxa | Measures the overall variety of the macroinvertebrate assemblage | number decreases |
| | Number of EPT taxa | Number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) | number decreases |
| Composition Metrics | % EPT | % of Ephemeroptera, Plecoptera, and Trichoptera | % decreases |
| | % OC | % of oligochaetes (worms) and chironomids (midges) | % increases |
| Tolerance Metrics | % Dominant | % contribution of single most dominant taxa | % increases |
| | NCBI | North Carolina Biotic Index which incorporates richness and abundance with a numerical rating of tolerance | number increases |
| Habit Metric | % Clingers | % of macroinvertebrates having fixed retreats or attach to surfaces | % decreases |

## **Results and Discussion**

East Fork Poplar Creek

The metric values, metric scores, overall index scores, and biological condition ratings of the impacted streams on the ORR are presented in Table 2. EFK 24.4 and EFK 23.4 rated partially supporting/moderately impaired compared to Bioregion reference conditions. Both sites had index scores of 14, 18 points lower than the target index score of 32. Stream conditions appeared to improve downstream as EFK 13.8 and EFK 6.3 had scores of 26 and 28, respectively, and had biological condition ratings of partially supporting/slightly impaired. Observed responses in the individual metrics coincided with those expected with an introduction of stress into the system (Table 1). Most noticeable were increases in the Taxa Richness, EPT Richness, % EPT, and % Clingers with distance from the Y-12 Plant. A near 40% reduction in the % OC between the two upper sites and the two lower sites indicated a greater degree of impact within plant boundaries. Sampling results continue to support the assessment of increasing water quality with distance from the Y-12 Plant and that conditions in Upper East Fork Poplar Creek continue to impact the biotic integrity of the system.

Mitchell Branch

MIK 1.43 and MIK 0.45 rated partially supporting/slightly impaired with identical index scores of 26. MIK 1.43 has long been considered an upstream reference site for MIK 0.71 and MIK 0.45 within ETTP. From Table 2, MIK 1.43 had twice the EPT Richness as MIK 0.45 and over five times the % EPT. MIK 0.71 lies within the remediated portion of Mitchell Branch and continued to have depressed numbers compared to the upper and lower site. The % EPT and to a greater extent the Taxa Richness at MIK 0.71 were lower compared to MIK 0.45. The degree of suitable habitat and the direct impact from source pollutants continue to limit the richness and composition of benthic macroinvertebrates in lower Mitchell Branch.

White Oak Creek and Melton Branch

White Oak Creek followed a trend of decreasing index scores and ratings with distance through the ORNL Plant (Table 2). Taxa Richness, EPT Richness, and % EPT decreased dramatically between WCK 6.8 and WCK 3.9, the latter being the uppermost sampling site inside the plant. These metric values, however, rebounded and gradually increased downstream of WCK 3.9. The effects of increased % OC and lower % Clingers with distance appeared to offset the apparent shift in improved water quality as the index scores and ratings remained depressed downstream. Results from the site along the Melton Branch tributary to White Oak Creek, MEK 0.3, fell within the range obtained at WCK 6.8 and WCK 3.9 producing an index score of 36 and a fully supporting/non-impaired rating.

Bear Creek

Compared to Bioregion conditions, the uppermost site on Bear Creek, BCK 12.3, rated partially supporting/moderately impaired and BCK 10.3 rated partially supporting/slightly impaired. Table 2 shows that the expected responses to a stressed system (from Table 1) were exhibited in Bear Creek. BCK 12.3 had a lower Taxa Richness, EPT Richness, % EPT, and % Clingers than BCK 10.3 and had greater % OC and % Dominant values than the downstream sampling site. Results indicate that water quality issues continue to plague Upper Bear Creek closest to the Y-12 Plant.

**Table 2. Metric Values, Scores, and Biological Condition Ratings for ORR streams, Spring 2003.**

| | East Fork Poplar Creek | | | | Mitchell Branch | | |
|---|---|---|---|---|---|---|---|
| **METRIC** | EFK 24.4 | EFK 23.4 | EFK 13.8 | EFK 6.3 | MIK 1.43 | MIK 0.71 | MIK 0.45 |
| Taxa Richness | 19 (2) | 19 (2) | 33 (6) | 20 (2) | 33 (6) | 24 (4) | 32 (6) |
| EPT Richness | 3 (0) | 3 (0) | 6 (2) | 4 (2) | 7 (2) | 3 (0) | 4 (2) |
| % EPT | 13.4 (0) | 7.9 (0) | 32.3 (4) | 38.4 (4) | 33.5 (4) | 5.6 (0) | 6.0 (0) |
| % OC | 78.1 (0) | 81.5 (0) | 56.4 (2) | 45.3 (4) | 48.9 (4) | 82.2 (0) | 57.4 (2) |
| NCBI | 3.01 (6) | 3.98 (6) | 5.23 (4) | 4.26 (6) | 4.76 (4) | 3.45 (6) | 4.42 (6) |
| % Dominant | 19.6 (6) | 36.0 (4) | 12.3 (6) | 19.2 (6) | 12.8 (6) | 39.4 (4) | 24.6 (6) |
| % Clingers | 17.9 (0) | 25.3 (2) | 31.8 (2) | 53.5 (4) | 13.3 (0) | 38.3 (4) | 43.2 (4) |
| INDEX SCORE | 14 | 14 | 26 | 28 | 26 | 18 | 26 |
| RATING | **C** | **C** | **B** | **B** | **B** | **C** | **B** |

| | White Oak Creek | | | | | Bear Creek | |
|---|---|---|---|---|---|---|---|
| **METRIC** | WCK 6.8 | WCK 3.9 | WCK 2.9 | WCK 2.3 | MEK 0.3 | BCK 12.3 | BCK 10.3 |
| Taxa Richness | 32 (6) | 19 (2) | 21 (4) | 28 (4) | 31 (6) | 23 (4) | 30 (4) |
| EPT Richness | 14 (6) | 5 (2) | 3 (0) | 6 (2) | 9 (4) | 3 (0) | 5 (2) |
| % EPT | 64.4 (6) | 32.6 (4) | 65.9 (6) | 15.1 (2) | 46.6 (6) | 8.9 (0) | 22.7 (2) |
| % OC | 12.5 (6) | 24.4 (6) | 27 (4) | 29.3 (4) | 29.4 (4) | 75.0 (2) | 58.7 (2) |
| NCBI | 3.04 (6) | 4.47 (6) | 3.76 (6) | 4.99 (4) | 3.99 (6) | 4.28 (6) | 5.44 (4) |
| % Dominant | 22.1 (6) | 20.8 (6) | 38.9 (4) | 19.5 (6) | 9.8 (6) | 27.6 (6) | 19.2 (6) |
| % Clingers | 57.7 (6) | 62.4 (6) | 31.4 (2) | 23.4 (2) | 49.54 (4) | 20.3 (2) | 27.9 (2) |
| INDEX SCORE | 42 | 32 | 26 | 24 | 36 | 20 | 22 |
| RATING | **A** | **A** | **B** | **B** | **A** | **C** | **B** |

Key:
**A** - Fully Supporting - Non-impaired………………………………… >= 32
**B** - Partially Supporting - Slightly Impaired……………………… 21 - 31
**C** - Partially Supporting - Moderately Impaired…………………… 10 - 20
**D** - Non-Supporting - Severely Impaired………………………… < 10

## Conclusions

The overall biotic integrity of streams on the ORR continues to be less than optimal compared to Bioregion reference conditions. Based on benthic macroinvertebrate community assessments, only two sites, both within the White Oak Creek watershed, showed signs of relatively non-impaired, fully supporting conditions. The remaining ten sites had biological condition ratings of slightly to moderately impaired systems. A trend of increasing water quality with distance from DOE influences existed within East Fork Poplar Creek and Bear Creek near the Y-12 Plant and Mitchell Branch at ETTP. Surface water sampling results in Bear Creek indicated nutrient enriched conditions continued to exist in the far upper reaches of the stream. White Oak Creek exhibited worsened conditions through decreased ratings as the creek flowed through the ORNL facility. A comparison between this year's sampling results to previous sampling results should be done with caution. The reported biological condition ratings are based on comparison of site index scores to the bioregion target index score. In previous years, ratings were based on scores compared to individual watershed reference stream scores. Continued assessments of benthic macroinvertebrate communities in ORR streams will add to the current database of information. Biomonitoring in this fashion would facilitate the capture of temporal and spatial changes in the aquatic systems due to DOE related activities. Environmental remedial actions taken by DOE continue to have an impact on the aquatic environments in East Fork Poplar Creek, Bear Creek, Mitchell Branch, and the White Oak Creek watershed. The effectiveness and usefulness of remedial activities would be documented through these water quality assessments.

**References**

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee. 2001.

*State of Tennessee Department of Environment and Conservation Division of Water Pollution Control Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys*, March, 2002. Revised November 2003.

Yard, C. R. 2002. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

# CHAPTER 3 DRINKING WATER

## Oversight and Independent Sampling of Oak Ridge Reservation Potable Water Distribution Systems for Bacteriological, Free Chlorine Residual, Radiological or Organic Content

Principal Author: Roger Petrie

**Abstract**

As the three Department of Energy (DOE) Oak Ridge Reservation (ORR) plants become more accessible to the public, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) has expanded its oversight of the DOE facilities' safe drinking water programs. The scope of the division's independent sampling includes oversight of potable water quality on or impacted by the ORR. The division conducted oversight of total coliform bacteria and free residual chlorine sampling at various buildings on the DOE ORR. Oversight of routine, monthly sampling activities allowed division personnel to become familiar with site potable water contacts in each plant's utility organization or subcontractor. In conjunction with these oversight activities, the division took independent samples of free chlorine residuals during site visits to monitor monthly sampling activities.

**Introduction**

Public consumption of the water on the Oak Ridge Reservation (ORR) continues to increase. In order to facilitate technology transfer, work for non-governmental sectors, and utilization of surplus buildings by private companies, security has been relaxed or reprioritized in recent years at some portions of the sites, most notably at East Tennessee Technology Park (ETTP). In turn, the composition of the workforce at the ORR has changed substantially. Oak Ridge National Laboratory (ORNL) has always hosted foreign dignitaries and accommodated visiting scientists in an openly cooperative manner. The other two sites, ETTP and Y-12, until recent years allowed only limited public visitation. Current facility use involves a substantial public presence at ETTP and ORNL, and to a lesser extent at Y-12. We did not investigate ETTP this year.

During May 2000 Department of Energy (DOE) transferred the Y-12 water treatment plant to the city of Oak Ridge. Both the ETTP and the former Y-12 water treatment plants withdraw surface water from the Clinch River, add coagulants to precipitate suspended sediment, use chlorine disinfectant, and filter water prior to distribution. As prescribed by *Tennessee Regulations for Public Water Systems and Drinking Water Quality - Chapter 1200-5-1,* most sampling focuses upon finished water at the treatment plant prior to distribution. State regulations require relatively little sampling at locations within distribution systems. The ORR potable water systems have been classified as non-community, non-transient systems. *Rule 1200-5-1-.07(1)(d)(3)* states that non-community water systems using surface water must monitor for total coliforms with the frequency required of like-sized community water systems. *Rule 1200-5-1-.31(5)(c)(3)* directs that residual disinfectant concentration be measured at the same times and locations that monthly microbiological contaminant samples are collected. Requirements set forth by *Rule 1200-5-1-.17(4)* mandate that not more than five percent of samples taken each month for two consecutive months contain less than 0.2mg/L free chlorine residual. Shown below (Table 1) is the minimum number of bacteriological samples required for each of the DOE distribution systems set forth by the sanitary surveys in effect at the close of calendar year 2003.

**Table 1. ORR Plant Populations and Required Samples**

| Facility | Estimated Population | Minimum Samples |
|---|---|---|
| ETTP | 2,500 | 2 |
| ORNL | 5,000 | 6 |
| Y-12 | 7,500 | 8 |

## Methods and Materials

Although the division will conduct independent sampling when situations indicate that the quality of drinking water in an ORR distribution system may be compromised or that the general integrity of the system is in doubt, the objective of this task was to conduct oversight of routine regulatory bacteriological and free residual chlorine monitoring at ETTP, ORNL, and Y-12. Coliform bacteria serve to indicate the presence of pathogenic organisms. A positive microbiological sample signals that pathogens may have entered the water supply due to inadequate initial treatment, poor sanitation, faulty line repair work, or cross connections to potable water distribution lines.

Division personnel used a Hach pocket colorimeter to measure free residual chlorine levels at all three facilities. Monitoring followed Method 4500-Cl G, DPD Colorimetric Method, outlined in the *Standards Methods for the Examination of Water and Wastewater, 20$^{th}$ Edition.* One of two small sample containers is reserved for a sample blank. A reagent, DPD powder, is added to the remaining container. The powder reacts with free chlorine present in the drinking water sample. A slight free chlorine residual results in a pale pink hue, whereas a high chlorine residual produces a deep cranberry color. The colorimeter then measures the concentration of free chlorine in the sample.

Bound logbooks, databases, and trip reports serve collectively to document the division's potable water oversight activities.

## Results and Discussion

Fifteen visits were made to oversee monthly bacteriological and free chlorine residual sampling. Sampling for free residual chlorine was done using the division's colorimeter. Table 2 summarizes the sampling results.

**Table 2. Oversight Visits - Observation of Monthly Sampling**

| Date of Visit | ORR Facility | Number of Bacteriological Samples Contractor | Lowest Free Chlorine Residual Contractor/TDEC (mg/L) |
|---|---|---|---|
| 01/06/03 | ORNL | 3 | 0.91/1.25 |
| 01/07/03 | Y-12 | 4 | 0.6/0.78 |
| 01/13/03 | ORNL | 3 | 1.28/0.86 |
| 02/04/03 | Y-12 | 4 | 0.7/0.80 |
| 02/10/03 | ORNL | 3 | 0.59/0.49 |
| 02/10/03 | ORNL | 3 | 1.44/1.27 |
| 03/03/03 | ORNL | 3 | 1.37/1.27 |
| 03/10/03 | ORNL | 3 | 1.55/1.42 |
| 03/11/03 | Y-12 | 5 | 0.3/0.42 |
| 04/07/03 | ORNL | 3 | 0.99/0.73 |
| 04/08/03 | Y-12 | 5 | 0.2/0.36 |
| 04/14/03 | ORNL | 3 | 1.57/1.50 |
| 05/05/03 | ORNL | 3 | 0.83/1.22 |
| 05/12/03 | ORNL | 3 | 1.64/1.62 |
| 05/13/03 | Y-12 | 5 | 0.5/1.22 |

## Conclusion

As can be seen in Table 2 no samples collected by the contractor or the division indicated chlorine levels to be below the regulatory limit of 0.2mg/L. Also, there were no samples reported to have elevated levels of bacteria above the regulatory limits. The division will continue to monitor the sample collection activities and if conditions warrant will collect free chlorine and/or bacteriological samples for comparisons.

## References


Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, eds. Washington, D.C: American Public Health Association, American Water Works Association, and Water Environment Federation, 20th ed. 1998. *Standard Methods for the Examination of Water and Wastewater.*

Tennessee Department of Environment and Conservation. *Regulations for Public Water Systems and Drinking Water Quality (Chapter 1200-5-1).* Tennessee Department of Environment and Conservation, Division of Water Supply. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Yard, C. R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 3 DRINKING WATER

## Implementation of EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program (RMO)

Principal Authors: Howard Crabtree, John Sebastian

**Abstract**

The Environmental Radiation Ambient Monitoring System was developed by the U.S. Environmental Protection Agency (EPA) to monitor potential pathways for significant population exposures from routine and/or accidental releases of radioactivity from major sources in the United States (U.S. EPA, 1988). This program provides for radiochemical analysis of finished water at five public water supplies located near and on the Oak Ridge Reservation. In this effort, quarterly samples are taken by personnel from the Tennessee Department of Environment and Conservation to be analyzed at the EPA's National Air and Radiation Environmental Laboratory in Montgomery, Alabama. Although, data from the program indicate tritium, gross beta, and strontiun-90 results are higher for the Gallaher Water Treatment Plant than the four other systems monitored in the program, the results received from EPA, to date, have all been well below regulatory criteria.

**Introduction**

Radioactive contaminants released on the Oak Ridge Reservation (ORR) enter local streams and are transported to the Clinch River. While monitoring of these streams, the river, and local water treatment facilities has indicated that concentrations of radioactive pollutants are below regulatory standards, there has remained a concern that area public water supplies could be impacted by ORR pollutants. In 1996, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division (the division) began participation in the Environmental Protection Agency's (EPA) Environmental Radiation Ambient Monitoring Systems (ERAMS). This program provides radiological monitoring of finished water at public water supplies near nuclear facilities throughout the United States. The ERAMS program was designed to:

1. Monitor pathways for significant population exposure from routine and/or accidental releases of radioactivity;
2. Provide data indicating additional sampling needs or other actions required to ensure public health and environmental quality;
3. Serve as a reference for data comparisons (U.S. EPA, 1988)

The ERAMS program also provides a mechanism to evaluate the impact (if any) of DOE activities on area water systems and validate DOE monitoring in accord with the *Tennessee Oversight Agreement* (TDEC, 2001).

**Methods and Materials**

In the Oak Ridge ERAMS Program, EPA provides radiochemical analysis of finished drinking water samples taken quarterly by division staff at five public water supplies located on and in the vicinity of the ORR. The samples are collected using procedures and supplies prescribed in *Environmental Radiation Ambient Monitoring System (ERAMS) Manual* (U.S. EPA, 1988). ERAMS analytical frequencies and parameters are provided in Table 1.

**Table 1: ERAMS Analysis for Drinking Water**

| ANALYSIS | FREQUENCY |
|---|---|
| Tritium | Quarterly |
| Gamma Scan | Annually on composite samples |
| Gross Alpha | Annually on composite samples |
| Gross Beta | Annually on composite samples |
| Iodine-131 | Annually on one individual sample/sampling site |
| Radium-226 | Annually on samples with gross alpha >2 pCi/L |
| Radium-228 | On samples with Radium-226 between 3-5 pCi/L |
| Strontium-90 | Annually on composite samples |
| Plutonium-238, Plutonium-239, Plutonium-240 | Annually on samples with gross alpha >2 pCi/L |
| Uranium-234, Uranium-235, Uranium-238 | Annually on samples with gross alpha >2 pCi/L |

The five Oak Ridge area monitoring locations are: Kingston Water Treatment Plant, Gallaher (K-25) Water Treatment Plant, West Knox Utility, city of Oak Ridge Water Treatment Facility (formerly DOE Water Treatment Plant at Y-12), and Anderson County Utility District. Figure 1 depicts the approximate locations of raw water intakes associated with these facilities.

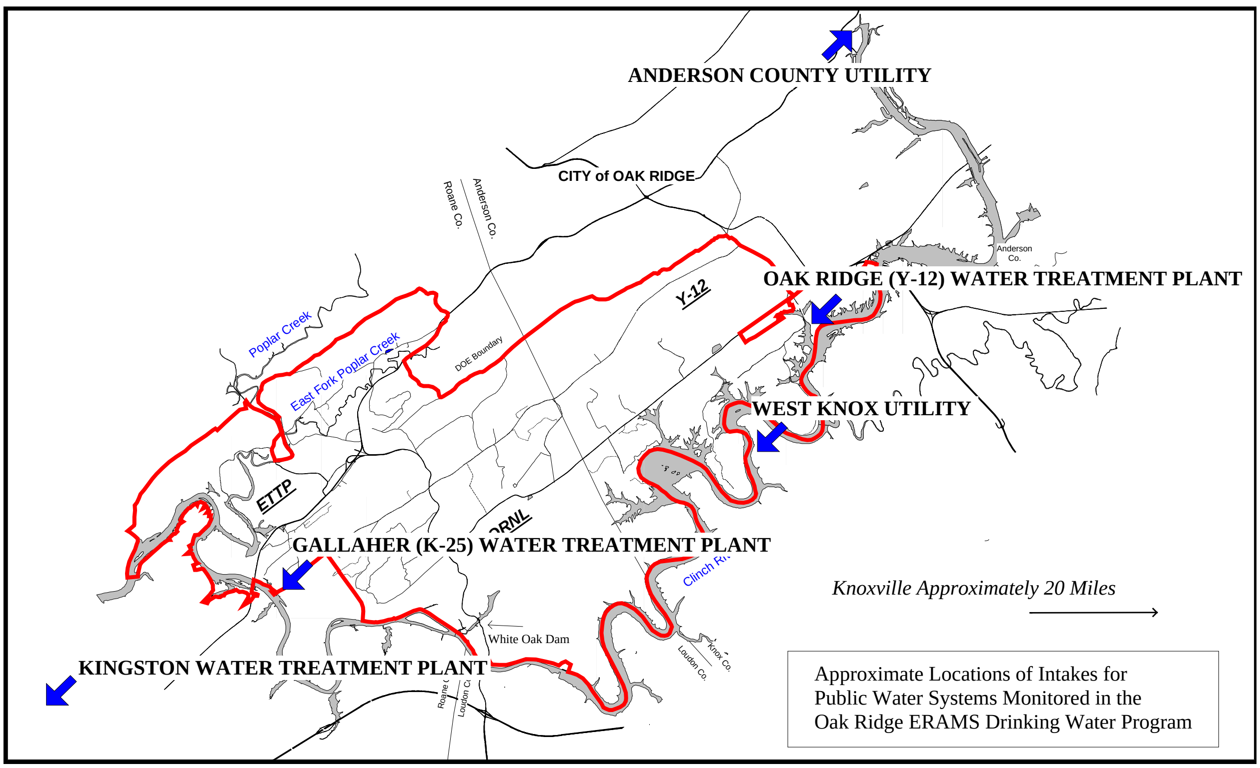


**Figure 1: Approximate Locations of the Intakes for Public Water Systems Monitored in Association with EPA's Environmental Radiation Ambient Monitoring System (ERAMS) Drinking Water Program**

**Results and Discussion**

A large proportion of the radioactive contaminants that are transported off the ORR in surface water enter the Clinch River by way of White Oak Creek, which drains the Oak Ridge National Laboratory complex and associated waste disposal areas. When contaminants carried by White Oak Creek and other ORR streams enter the Clinch, their concentrations are significantly lowered by the dilution provided by the waters of the river. With exceptions, contaminant levels are further reduced in finished drinking water by conventional water treatment practices used by area utilities. Consequently, the levels of radioactive contaminants measured in the Clinch and at area water supplies are far below the concentrations measured in White Oak Creek and some of the other streams on the ORR.

Since the Gallaher Water Treatment Plant is the closest water supply downstream of White Oak Creek (approximately 6.5 River Miles), this facility would be expected to exhibit the highest concentrations of radioactive contaminants of the five utilities monitored in the program. Conversely, the Anderson County Facility (located upstream of the reservation) would be expected to be the least vulnerable to ORR pollutants.

Based on the data collected since the Oak Ridge ERAMS Program began in July 1996, the above appears to be the case. However, the results for the Gallaher Facility, as well as the other sites, have all remained well below applicable drinking water standards. A brief summary of the results received since Oak Ridge program began is provided below.

- Since 1997, gross alpha, gross beta, and strontium-90 analysis has been performed annually on a composite of the quarterly samples taken from each facility. The results from this analysis were all below 0.5 pCi/L, compared to a drinking water standard of 15 pCi/L. The results for the 2003 analysis were not available at the time of this report.
- The highest gross beta result for the annual composite analysis was reported for the Gallaher Facility, which averaged 3.33 pCi/L with a maximum concentration of 3.86 pCi/L. The drinking water standard for beta emitters depends on the specific radionuclides present, but radionuclide specific analysis is generally not required at gross beta levels below 50 pCi/L.
- Of twenty composite samples analyzed for strontium-90 (a beta emitter), the only results reported above detection limits were for samples taken at the Gallaher Facility. These results indicate three of the four samples analyzed had low, but detectable, amounts of the radionuclide. The average result was 0.64 pCi/L and the data ranged from 0.29 to 0.99 pCi/L. The drinking water standard for strontium-90 is 8 pCi/L.
- Analysis for iodine-131 was performed each year since 1996 on one sample from each facility. The radionuclide was only reported as detected in one of twenty-six samples analyzed. This result, 0.3 pCi/L, was from a sample taken upstream of the reservation, making the validity of the measurement suspect. The standard for iodine-131 is 3.0 pCi/L.
- Tritium is a not readily removed by conventional treatment processes and is one of the most prevalent contaminants discharged by White Oak Creek into the Clinch River. ERAMS performs tritium analysis on each of the quarterly samples taken at facilities in the program. Of the 152 tritium results reported for the five Oak Ridge Treatment Plants, only 22 were above detection limits. Of the results above detection limits, 19 were for samples taken from the Gallaher Facility and three were reported for the Kingston Facility, further downstream. The results for tritium at the Gallaher Facility ranged from undetected to 1000 pCi/L and averaged 311 pCi/L. The drinking

water standard is 20,000 pCi/L. Figure 2 depicts the average tritium concentration at each facility over the lifetime of the program.

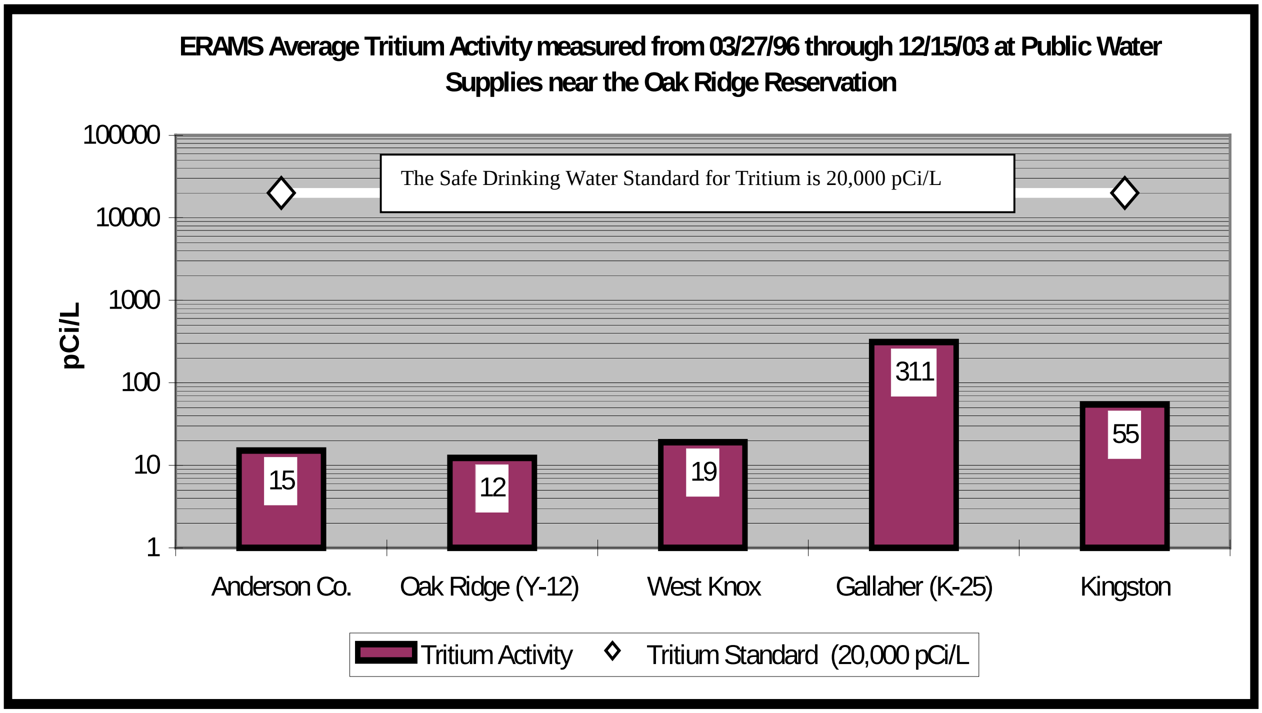


**Figure 2: Average Tritium Results for Samples of Finished Drinking Water taken at Oak Ridge Area Water Treatment Facilities in association with EPA's ERAMS Program (03/27/96-12/15/03)**

The data currently available for 2003 (Table 2) consists of iodine-131 and tritium results for only a portion of the samples taken. Of the 2003 data reported to date, all of the results for iodine-131 were below detection limits. The only tritium result above detection limits was 540 pCi/L for a sample taken at the Gallaher Facility.

## Conclusion

Radioactive contaminants migrate from the ORR to the Clinch River, which serves as a raw water source for area public drinking water supplies. The impact of these contaminants is diminished by dilution provided by waters of the Clinch. Contaminant concentrations are further reduced in finished drinking water by conventional water treatment practices employed by area utilities. ERAMS results over the last six years (when the program began) have all been well below drinking water criteria. While well below drinking water standards, gross beta, strontium-90, and tritium have all been reported at higher levels in samples taken from the Gallaher Water Treatment Plant than the other facilities monitored in the program. In this respect, the Gallaher plant is the closest facility downstream of White Oak Creek, the major pathway for radiological pollutants entering the Clinch from the ORR.

**Table 2: 2003 ERAMS Tritium Results for Drinking Water in the Oak Ridge Area (pCi/L)**

| Water Treatmant Facility | Sampling Date | Result | Error | MDL | Standard |
|---|---|---|---|---|---|
| Anderson Co | 03/18/03 | 17 | 70 | 119 | 20,000 |
| Anderson Co | 05/20/03 | 55 | 74 | 123 | 20,000 |
| Anderson Co | 08/19/03 | -2 | 78 | 133 | 20,000 |
| Anderson Co | 12/15/03 | 28 | 75 | 128 | 20,000 |
| Oak Ridge (Y-12) | 03/26/03 | -4 | 82 | 141 | 20,000 |
| Oak Ridge (Y-12) | 08/19/03 | 24 | 79 | 133 | 20,000 |
| Oak Ridge (Y-12) | 12/15/03 | 19 | 75 | 127 | 20,000 |
| Knox Co | 03/18/03 | 27 | 71 | 120 | 20,000 |
| Knox Co | 05/20/03 | 16 | 72 | 122 | 20,000 |
| Knox Co | 07/29/03 | 35 | 73 | 122 | 20,000 |
| Knox Co | 11/13/03 | 109 | 76 | 122 | 20,000 |
| Kinston | 03/24/03 | 20 | 81 | 138 | 20,000 |
| Kinston | 05/29/03 | 8 | 75 | 128 | 20,000 |
| Kinston | 08/01/03 | -7 | 71 | 123 | 20,000 |
| Kinston | 12/02/03 | 82 | 75 | 122 | 20,000 |
| Gallaher (K-25) | 03/26/03 | 540 | 100 | 137 | 20,000 |
| Gallahar (K-25) | 08/01/03 | 29 | 72 | 122 | 20,000 |

**References**


Tennessee Department of Environment and Conservation, 2001. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2002.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

U.S. Environmental Protection Agency (EPA), 1988. *Environmental Radiation Ambient Monitoring System (ERAMS) Manual.* EPA 520/5-84-007, 008, 009.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 3 DRINKING WATER

## Radiological Analysis of Drinking Water at Oak Ridge National Laboratory

Principal Author: Roger Petrie


### Abstract

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted sampling of drinking water at Oak Ridge National Laboratory (ORNL) for radiological contaminants. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of Core Hole 8. Results of the sampling indicate that at the time of sampling there were no radiological contaminants in the drinking water system in the vicinity of Core Hole 8.


### Introduction

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted sampling of drinking water at Oak Ridge National Laboratory (ORNL) for radiological contaminants. This sampling addressed the possible infiltration of radiological contaminants into the ORNL drinking water distribution system in the vicinity of Core Hole 8.

This area has been identified as having extensive subsurface radiological contamination. In addition, the sampling will aid in the identification of infiltration that may be occurring. This plan also serves as a template for additional sampling at ORNL, or the other DOE facilities, in the event of a large pressure drop of the distribution system due to major failure or significant water loss from firefighting or flushing.

### Methods and Materials

Analysis of distribution maps and schematics was utilized to identify five locations in the area of Core Hole 8. The sites and dates sampled are shown in Table 1.

**Table 1. Locations of Drinking Water Sampling at ORNL**

| Site | Date |
|---|---|
| Bldg. 3137 | 4/21/2003 |
| Bldg. 2010 | 4/21/2003 |
| Bldg. 2018 | 4/21/2003 |
| Bldg. 2525 | 4/21/2003 |
| Bldg. 2518 | 4/21/2003 |

The samples were analyzed for presence of bacteria, gross alpha and beta emitters, and gamma radionuclides.

When other locations are being sampled, the parameters analyzed will vary depending upon the contaminants of concern in the area of the distribution system failure. The parameters analyzed will be chosen from process knowledge and other gathered data, (e.g., plume maps, Remedial Investigations etc.).

## Results and Discussion

All five samples collected tested negative for the presence of bacteria. The results of the analysis for gross alpha and beta emitters are shown in Table 2. These results indicate that there is no contamination present that can be attributed to alpha or beta emitters.

**Table 2. Results of Gross Alpha and Beta Analysis (pCi/L)**

| Site | Gross Alpha | Gross Beta |
|---|---|---|
| Bldg. 3137 | -2.0 ± 2.4 | 2.4 ± 2.3 |
| Bldg. 2010 | -1.9 ± 2.3 | 1.8 ± 2.2 |
| Bldg. 2018 | -0.5 ± 2.5 | 0.1 ± 2.1 |
| Bldg. 2525 | -1.6 ± 2.5 | 3.1 ± 2.3 |
| Bldg. 2518 | -2.9 ± 2.2 | 3.2 ± 2.3 |

The results of the analysis for gamma radionuclides are shown in Table 3. These results show the presence of only naturally occurring radinuclides at levels that do not pose a risk to human health.

**Table 3. Results of Gamma Radionuclide Analysis (pCi/l).**

| Site | Pb-212 | Pb-214 | Bi-212 | Bi-214 | Ac-228 | Tl-208 |
|---|---|---|---|---|---|---|
| Bldg. 3137 | | 16.7 ± 3.8 | 38.0 ± 3.8 | 52.3 ± 6.5 | | |
| Bldg. 2010 | 8.4 ± 2.1 | 21.2 ± 3.3 | | 21.7 ± 3.6 | | |
| Bldg. 2018 | | 21.0 ± 3.3 | | 27.0 ± 3.8 | | |
| Bldg. 2525 | 5.6 ± 1.9 | 26.8 ± 3.5 | | 25.8 ± 3.7 | | 5.6 ± 1.6 |
| Bldg. 2518 | | 26.7 ± 3.5 | | 25.1 ± 3.5 | 17.1 ± 4.7 | |

## Conclusion

Based on the results of the analysis conducted on the samples, there is no evidence at this time that there is any intrusion of contaminants from the Core Hole 8 area into the ORNL drinking water distribution system. It should be noted that these were grab samples, which represent a snapshot in time, and does not mean that contamination will not be present in the future.

## References


Craun, G. F., N. Nwachuku, R. L. Calderon, M. F. Craun. July/August 2001. Outbreaks in drinking-water systems, 1991-1998. *Journal of Environmental Health*. pp. 16-23.

Eaton, A.D., L.S. Clesceri, and A.E. Greenberg, editors. 2000. *Standard Methods for the Examination of Water and Wastewater*, 20th edition. American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, DC.

Lahlou, Zacharia Ph.D., May 2001. Tech Brief, Leak *Detection and Water Loss Control*. National Drinking Water Clearinghouse. Morgantown, West Virginia.

Tennessee Department of Environment and Conservation. *Regulations for Public Water Systems and Drinking Water Quality (Chapter 1200-5-1).* Tennessee Department of Environment and Conservation, Division of Water Supply. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. *Tennessee Safe Drinking Water Act.* (T.C.A. 68-13-701). Nashville, Tennessee.

U.S. Environmental Protection Agency (EPA). *Cross Connection Control Manual*. EPA 570/9-89-007. June 1989.

Yard, C. R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 4 GROUNDWATER MONITORING

## Oak Ridge Reservation and Vicinity Independent Sampling Report

Principal Authors: Donald F. Gilmore, Robert C. Benfield

### Abstract

*Description of program – Scope of Monitoring*

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducts independent groundwater sampling at springs and wells on or near the Oak Ridge Reservation. The calendar year 2003 groundwater-sampling projects included six (6) separate residential sources and seventeen (17) exit pathway springs. Residential water sources were monitored for the presence of DOE related nuclear waste. Exit pathway springs in the peripheral areas of the Oak Ridge Reservation were monitored for determination of quality and effectiveness of DOE's monitoring and surveillance programs. Also, one (1) monitoring well was co-sampled as an independent oversight activity. Chapter Four (4) provides a status/review of the division's Environmental Monitoring & Compliance Program's Groundwater Section's findings based on sampling performed during calendar year 2003. Residential wells showed no evidence of contamination. Spring sampling showed that contamination exists beyond mapped plume boundaries.

### Introduction

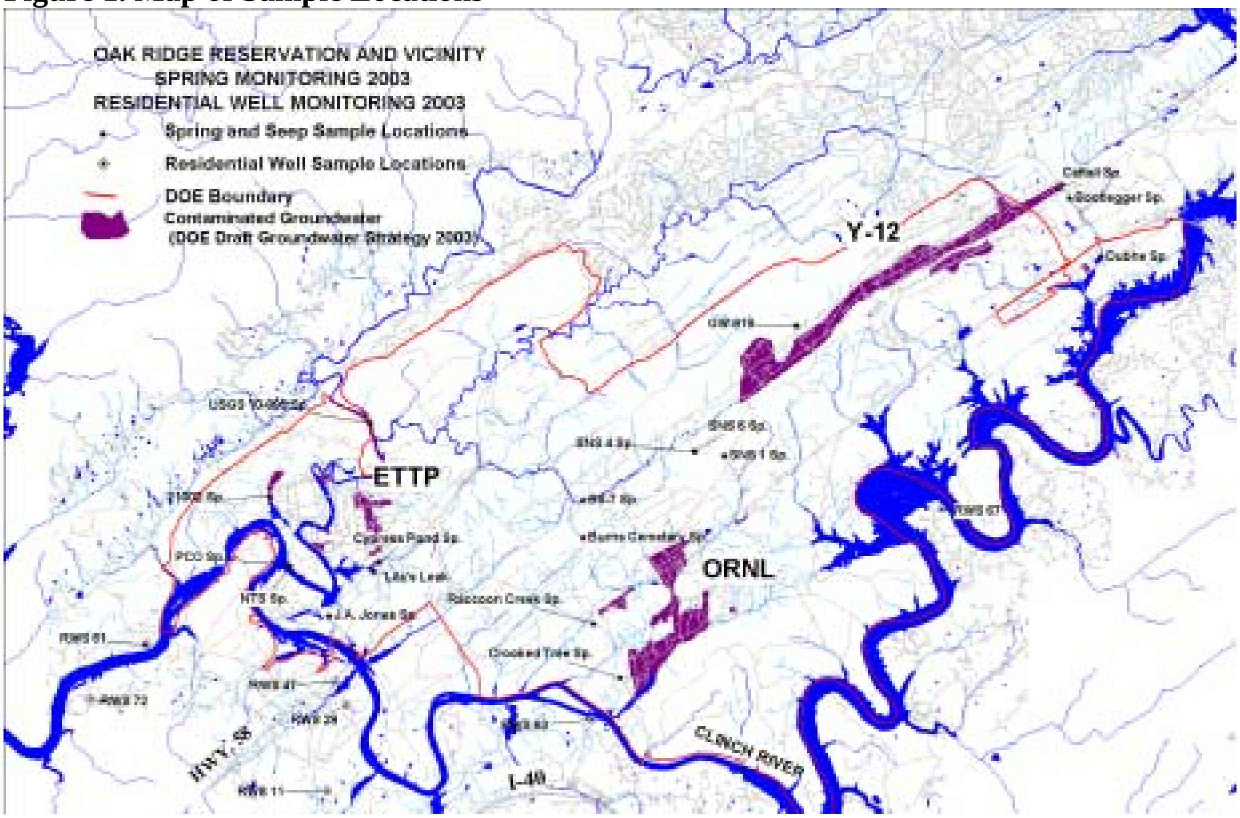
This chapter provides a status/review of the division's Environmental Monitoring & Compliance

**Table 1 List of sites sampled CY2003**

| Site | Station | Residential Water Sources |
|---|---|---|
| ETTP (K-25) | 21002 Sp. | RWS 11 |
| | Cyprus Root Pond Spring | RWS 29 |
| | J. A. Jones Sp. | RWS 47 |
| | Lila's Leak Spring | RWS 61 |
| | NTS Seep | RWS 67 |
| | PCO Seep | RWS 72 |
| | USGS 10895 | |
| ORNL (X-10) | Burns Cem. | |
| | Crooked Tree Sp. | |
| | Dubhe Sp. | |
| | Raccoon Creek Sp. | |
| | SNS-1 Sp. | |
| | SNS-4 Sp. | |
| | SNS-6 Sp. | |
| Y-12 | Bootlegger Sp. | |
| | Cattail Sp. | |
| | SS-7 Sp. | |
| | GW-919 | |

Program's Groundwater Section's findings. The Groundwater Section' staff sampled seventeen (17) springs, and six (6) residential water sources and one (1) monitoring well (Table 1). These findings are based on sampling performed during calendar year 2003 (CY2003) (See Figure 1 Map. Additional information on the division's sampling of groundwater may be found in chapters

**Figure 1. Map of Sample Locations**




on waste management and radiological monitoring. For organizational purposes at this juncture, the residential water sources are addressed separately from the exit pathway springs with the former monitored for nuclear waste and the latter for illumination of DOE's opportunities to improve monitoring groundwater. The Tennessee Oversight Agreement (TOA) specifies the state to prepare a report of sampling results. Also the TOA mentions the reporting of *findings* based on the state's analytical results. With respect to the TOA's requirements and the following definitions, this chapter attempts to integrate results and findings as an independent groundwater monitoring report.

- To monitor is to measure (gauge, calculate, determine, assess, quantify, evaluate, appraise, etc.) some aspect of groundwater;
- To sample is to extract some portion of a larger system of groundwater for testing.

In essence the state is not responsible for the groundwater monitoring on the Oak Ridge Reservation. Rather it is DOE's responsibility to "monitor and surveil" groundwater contamination. It is the state's duty to collect samples that verify DOE's programs are adequate. The state is not limited to this duty and "independent oversight," "independent monitoring," "supplemental monitoring" and other specific actions occur as a result of oversight.

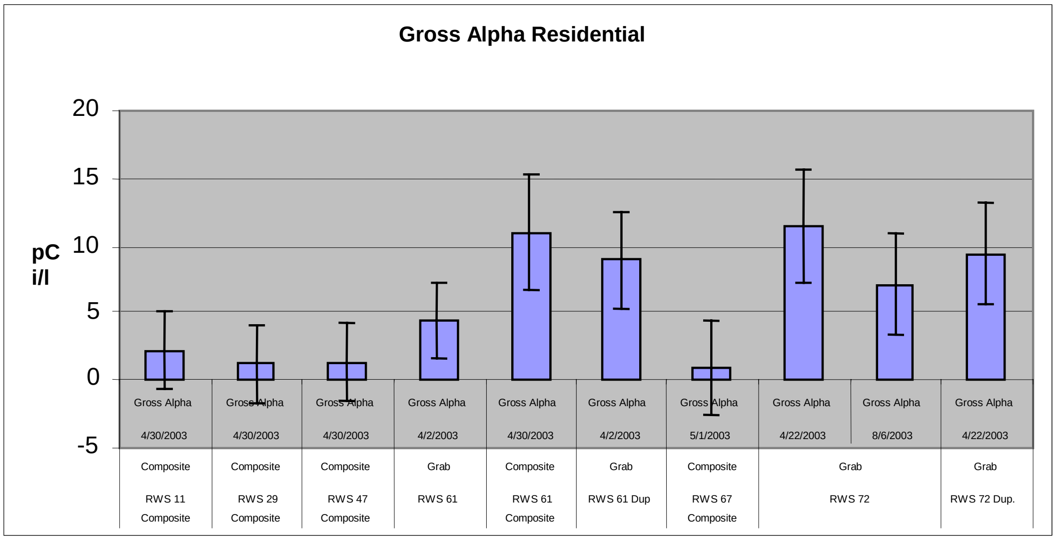



**Figure 2.** Graph of results showing elevated levels of gross alpha above typical 3 to 5 pCi/l in well 72 and 61. When values are close to 15 pCi/l specific isotopic and additional testing is done. Note there is not an applicable regulatory limit for Gross Alpha in groundwater.

The calendar year 2003 data collected both as grab and composite samples did not indicate the presence of DOE nuclear waste in the residential water wells. Two of the six wells' gross alpha levels approached a 15 Pico Curie per Liter value. Upon additional testing these two wells, located along geologic strike to the East Tennessee Technology Park, did not show either enriched or depleted uranium. The gross alpha at these two wells is considered to be a result of radon gas natural decay.

*Exit Pathway Springs*

Nearly every year the division discovers a contaminated and unmonitored new spring i.e. a spring not in any of the DOE surveillance programs. For example, during calendar year 2003 a new spring situated on the East Tennessee Technology Park property was dubbed J. A. Jones Spring and shows impacts by petroleum products, volatile organic compounds and nuclear waste. While DOE's monitoring programs are substantial with respect to the number of contaminated wells and sites, there are doubts to the program(s) effectiveness. Partly this can be attributed to the challenge of monitoring in East Tennessee's complex hydrogeologic setting, yet the responsibility is with DOE to surpass difficulties and provide a comprehensive program. Auspiciously, DOE has a surveillance program to assist monitoring for regulatory compliance. Surveillance data helps to draw plume maps among other things. Unfortunately, DOE plume maps often understate the extent of impacts to groundwater. It is the distant portions of groundwater, sometimes termed the exit pathways, where levels of the contaminants are often unacceptable. The aquifers and the "aquitard aquifers" in east Tennessee are vulnerable to contamination and plumes spread rapidly. For this and other reasons, contact with groundwater should be avoided. This concern is echoed in DOE's position to control through deed restrictions or notices many areas of groundwater use. Calendar year 2003 data shows a need for additional monitoring to provide adequate information to the public on past and current releases.

## Methods and Materials

The state environmental laboratory conducts the analysis of the water samples for radionuclides, volatile organic compounds, selected metals, nutrients, and inorganic parameters. The division's spring sampling activities typically include the parameters found in Table 2.

1. Finding new springs. Springs are normally found by walking along creeks and valleys and

**Table 2. Parameters**

| Nutrient, Metal & General Inorganic Analysis | Radiological Analysis | List of TCL* Volatiles |
|---|---|---|
| Metals | Typically | Acetone |
| Arsenic | Gross Alpha | Benzene |
| Barium | Gross Beta | Bromodichloromethane |
| Cadmium | Gamma Emitters | Bromoform |
| Calcium | Tritium | Bromomethane |
| Copper | | 2-Butanone (MEK) |
| Iron | If suspected then isotopes of: | Carbon Disulfide |
| Lead | Strontium | Carbon Tetrachloride |
| Magnesium | Technetium | Vinyl Acetate |
| Mercury | Uranium | Chlorobenzene |
| Nickel | Radium | Chloroethane |
| Potassium | | Chloroform |
| Selenium | | Chloromethane |
| Sodium | | Dibromochloromethane |
| Thallium | | 1,1-Dichloroethane |
| | | 1,2-Dichloroethane |
| General Inorganics | | 1,1-Dichloroethene |
| pH | | Cis-1,2-Dichloroethene |
| Specific Conductivity | | Trans-1,2-Dichloroethene |
| Total Alkalinity | | 1,2-Dichloropropane |
| Suspended Residue | | Cis-1,3-Dichloropropene |
| Dissolved Residue | | Trans-1,3-Dichloropene |
| Sulfate | | Ethylbenzene |
| Chloride | | Methylene Chloride |
| | | 4-Methyl-2-Pentatone (MIBK) |
| | | Styrene |
| Nutrients | | 2-Hexanone |
| NO3&NO2 Nitrogen | | 1,1,2,2-Tetrachloroethane |
| | | Tetrachloroethene |
| | | Toluene |
| | | 1,1,1-Trichloroethane |
| | | 1,1,2-Trichloroethane |
| | | Trichloroethene |
| | | Vinal Chloride |
| | | o-Xylene |
| | | m & p xylene |
| | | *TCL (Target Compound List) |

found often emerging in streambeds. Frequently watercress plants are associated with the appearance of springs. Careful use of temperature and specific conductivity measurements help delineate groundwater resurgences. In the areas of contaminant plumes, orange staining caused by iron related bacteria breaking down organic compounds also helps identify a location to sample. Smells or odors that may be sweet or stringent may contribute to the ability of locating a spring. However, if odors are noticed, steps should be taken to notify others of the potential hazards.

2. Field sampling. A sampling team locates the spring and collects the prescribed number of samples. The personnel wear disposable vinyl gloves while collecting samples. Sample labels (tags) and analysis request/chain of custody forms are completed. Samples are transported in coolers to the division's office for temporary storage, or may be taken directly to the Knoxville Basin Laboratory. Duplicate samples, trip blanks, and field blanks are taken as directed by the sampling plan.

3. Data Storage. Analytical results are stored in regular files in the DOE-O office, and the results are entered in a computer database. Eventually this data will be placed onto DOE's Oak Ridge Environmental Information System database. Copies of the lab analyses are periodically provided to DOE upon request.

## Results and Discussion

*Residential Groundwater Sources General*

The Clinch River appears to be the only natural feature buffering residential water sources from DOE groundwater impacts. This statement pertaining to the Clinch River as a hydrologic divide for groundwater predominantly stands true. Many springs issue along the riverbed in support of this statement. The critical base flow elevation of groundwater is not known. The area is underlain by karst aquifers and conduits may exist that have base levels below the Clinch River. There is a concern in the vicinity of the Hydrofracture underground waste injection projects that large pressures exerted during waste disposal potentially could also have had the force to underflow the Clinch River. The critical locations where monitoring by DOE needs to take place both on and off DOE property is in conjunction hydrofracture injection at Oak Ridge National Lab (ORNL or X-10).

*Residential Groundwater Sources CY2003*

Only radiochemistry samples were taken at the residential water sources with metals, volatile organic analytes, and general inorganic parameters curtailed. The decision to only test for nuclear waste is based on the fact DOE would be the only likely generator of such waste. On the other hand, the large amount of volatile compounds released to the environment on the Oak Ridge Reservation (ORR) has caused some of the longest recognized solvent plumes in groundwater. For this reason the volatile organic compounds (VOCs) also have been very good indicators of plume pathways. The best chance of finding volatile compounds however is in springs or monitoring wells rather than a well with a submersible pump. In the typical residential well the volatile compounds could be stripped from the water by the vigorous pumping action. Also there is a chance that solvents used by the public could cause local impacts. Based on radiological results, hydrogeology, discoloration or smells, the suite of parameters to test for in the residential well water may be expanded to further understand the aquifer characteristics and impacts. Residential wells numbers 61 and 72 showed elevated levels of gross alpha and additional sampling was performed to identify a possible cause. Upon isotopic analysis for uranium residential well number

72 did not appear to have uranium as the source of alpha. Radon is the likely responsible for elevated gross alpha in Residential well number 72. Residential well number 61 upon repeated test did not show elevated gross alpha. (See Figure 2)

Calendar year 2003 was the first attempt at composite sampling for radiochemistry at the residential wells by DOE-Oversight. The CY 2003 results indicate no nuclear waste from DOE in the wells tested.

*Exit Pathway Springs General*

In general terms the compliance monitoring shows heavily contaminated groundwater near spills and releases on the ORR. At several springs near Y-12 and East Tennessee Technology Park (ETTP or K-25) vapors in and near discharge points are conspicuous. Elsewhere springs indicate

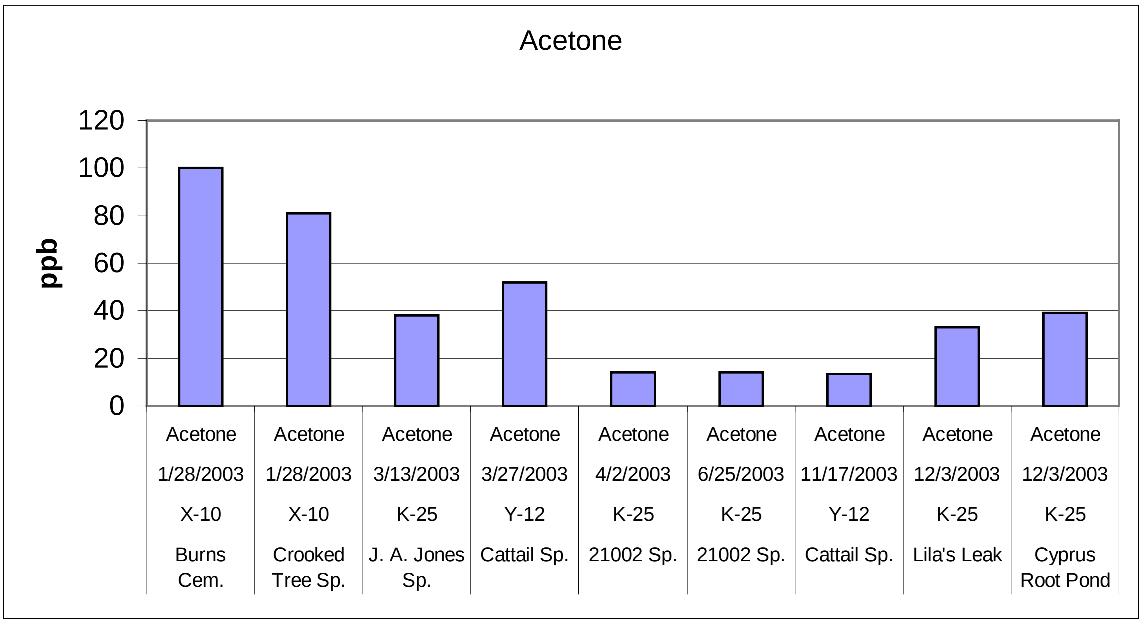



**Figure 3**: Acetone

suspected mobilizing of contaminants from remediation efforts (see Bone Yard Burn Yard discussion in radiological monitoring chapter). For example, monitoring at spring 21-002 showed an increase of contaminant flux while remediation of the K-1070A trenches occurred. In the future DOE is recommended to monitor these types of discharges during source term removal and document the short term and long-term changes to the environment higher water table conditions also appear to have had an effect altering concentrations at the University of Tennessee's Bootlegger Spring. For the first part of the year Bootlegger's VOCs were below detection. It was late in the year at lower spring flows when the signature of the Security Pits plume reappeared. It is suspected the Security Pits plume may be migrating down dip. Security Pits plume appears to be unstable. Just because sampling does not find contamination for extend periods, continued presence in the University of Tennessee's Arboretum is a fact.

A related monitoring concern is locations becoming inundated with ponds. Beaver ponds are causing trouble in monitoring at locations like SS-7 and Merak spring. To facilitate long term oversight and monitoring some of the locations will have to have either animal controls or other measures to allow monitoring.

The chemical acetone is becoming an important result to assess exit pathways. Acetone was found in several locations during sampling this year (see X-10 discussion below). It is not known for certain that these are not lab artifacts except in the case of Lila's Leak and Cyprus Root Pond Spring (See Figure 3). The lab reported samples from these two locations were valid given that other samples run on the gas chromatographs before and after did not show acetone. Next year will require field and trip blanks to help resolve issues that may arise.

*Exit Pathway Springs ETTP (K-25)*

Two more new springs at K-25, one named Lila's Leak and the other Cyprus Root Pond Spring are impacted with acetone at 32.9 ppb and 39.2 ppb respectively. From a hydrogeologic view these two new K-25 springs seem to be associated with groundwater resurgence along the Whiteoak Mountain Fault zone. Additional sampling is anticipated at numerous springs and the few wells along this fault zone. It appears this fault zone may be a poorly monitored exit pathway from the ETTP (K-25 site) (See Figure 4).

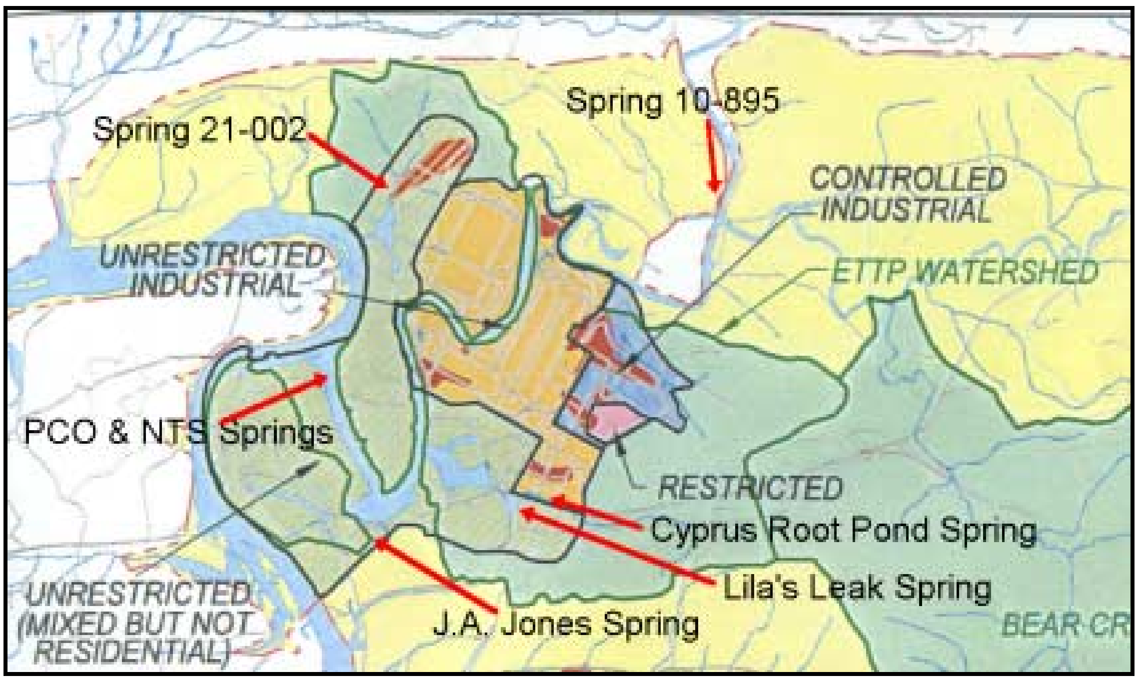



**Figure 4. Map of K-25 area showing plumes as red or dark patches. Spring locations are not near mapped plumes except Spring 21-002. To achieve effective monitoring plumes will have to be better understood in relation to impacted springs**

Another new spring at K-25 was sampled and showed very impacted groundwater. This K-25 spring was dubbed J. A. Jones Spring and shows impacts by petroleum products, VOCs, and radionuclides. Care should be taken in the vicinity of J. A. Jones Spring due to potential inhalation hazards. J. A. Jones Spring specifically shows noxious compounds vinyl chloride, and cis-1,2-Dichloroethene due to breakdown of TCE. (See Figure 5)

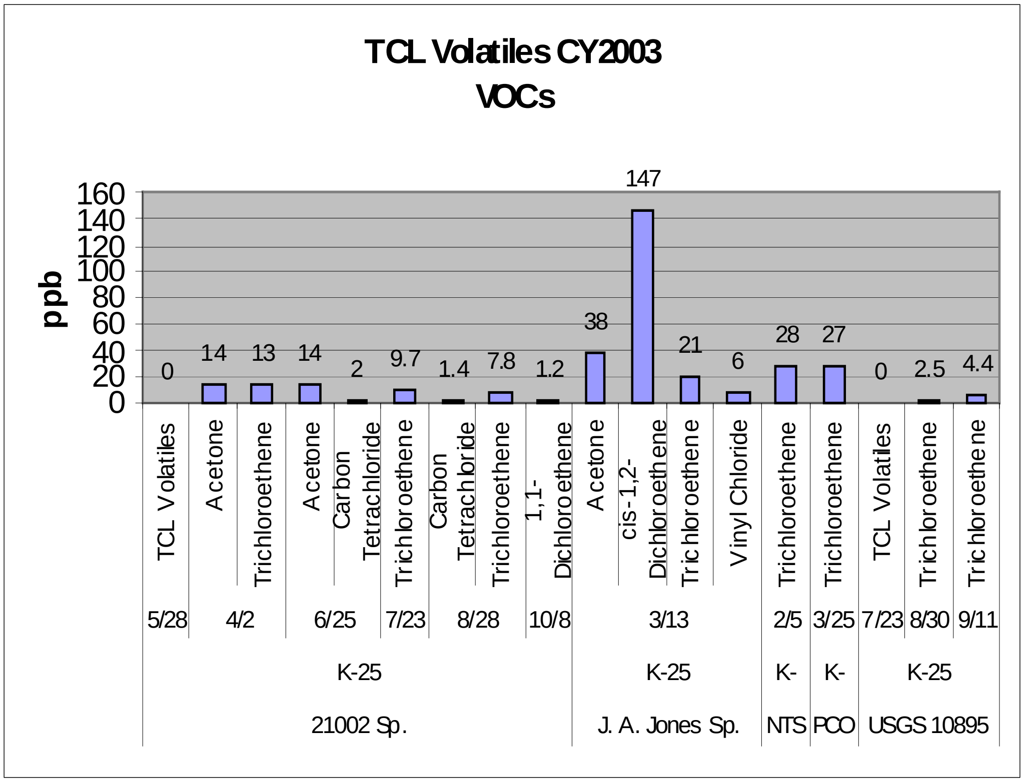



**Figure 5. East Tennessee Technology Park (K-25) Volatile Organic Analysis results.**

From a groundwater standpoint, monitoring in and around ETTP is weak. Plumes are not well defined and sampling continues to show the presence of plumes well beyond mapped plumes. For the most part a mistake is made in saying no contamination exist where there are no wells. There is a significant need for more wells and groundwater tracing to understand the distribution of contaminated water at ETTP. Exit pathway springs should be monitored for both releases and remediation effects.

*Exit Pathway Springs X-10*

Burns Cemetery Spring and Crooked Tree Spring were sampled on the same date. Results show both have acetone. This is somewhat suspect, as these springs do not generally show VOCs. Acetone will be looked into more and exacting procedures will be employed to help eliminate errors. Burns Cemetery Spring is not shown on the map but is north of Raccoon Creek Spring at the top of the Bethel Valley Watershed. (See Figure 6)

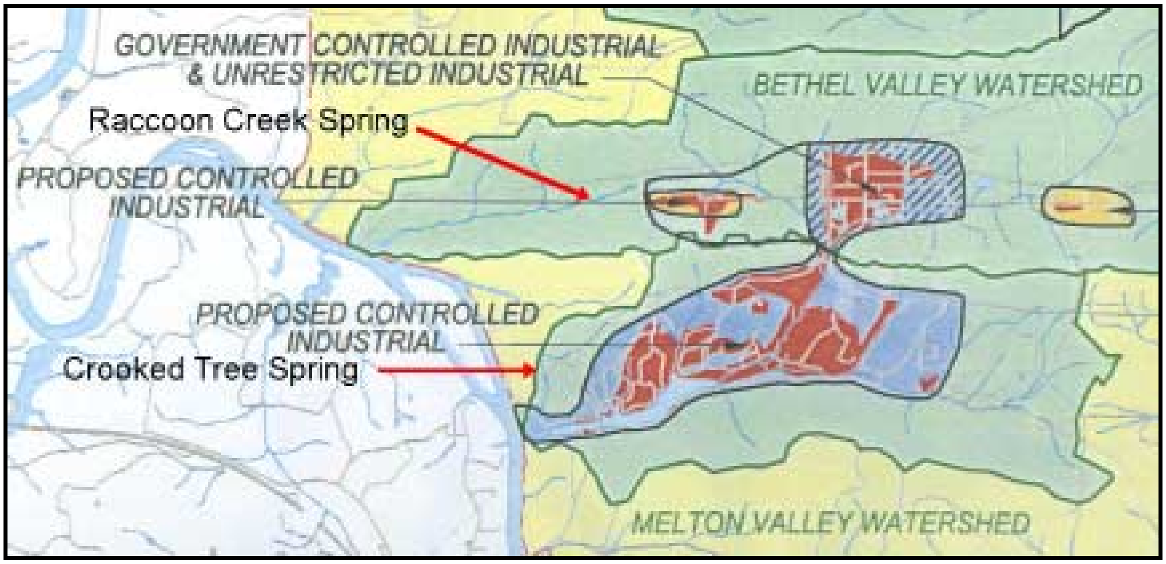



**Figure 6. Oak Ridge National Laboratory (ORNL or X-10) Note plume pathways are not drawn to impacted springs**.

Crooked Tree Spring radiochemistry results show elevated levels for Tritium in comparison to other sampling points for CY2003. (See Figure 7)

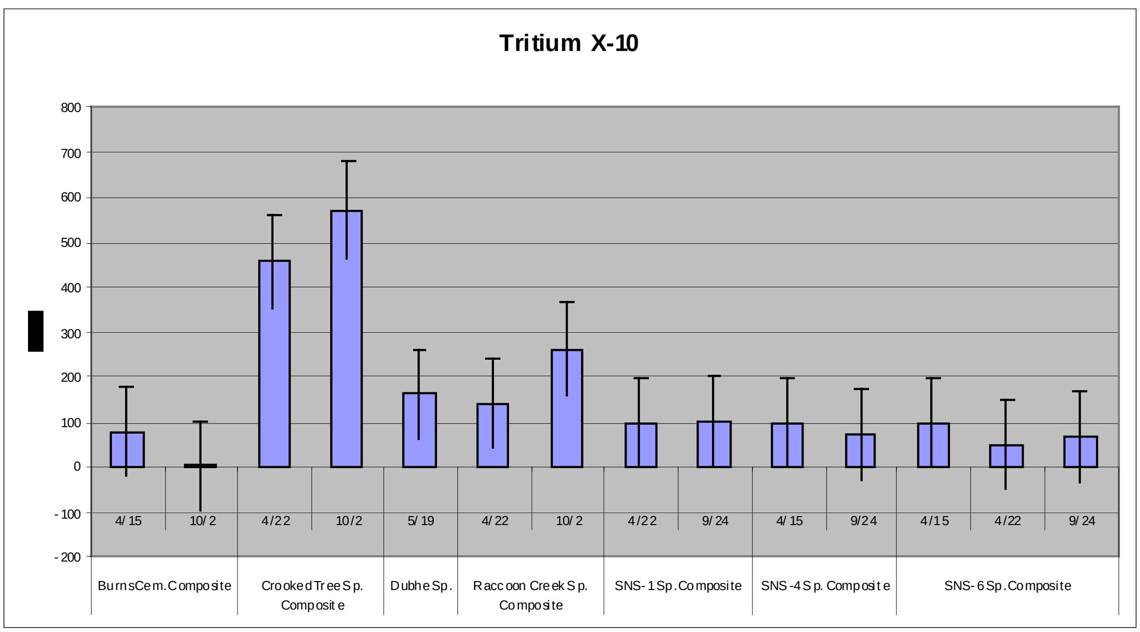



**Figure 7. Tritium results. There is an drinking water limit of 20,000pCi/l H-3. All groundwater results are below this drinking water value. Where values are higher than typical results is in relation to releases at X-10**.

Exit Pathway Springs Y-12

Bootlegger Spring in the University of Tennessee Arboretum has shown through past sampling VOAs associated with the Security Pits disposal area on Chestnut Ridge near Y-12. Sampling this spring twice a year during these wetter times of the past two years was not enough to see the typical signature of organic compounds. Sampling throughout the year revealed during lowest water table conditions that the organics once again could be seen. (See Figures 8&9)

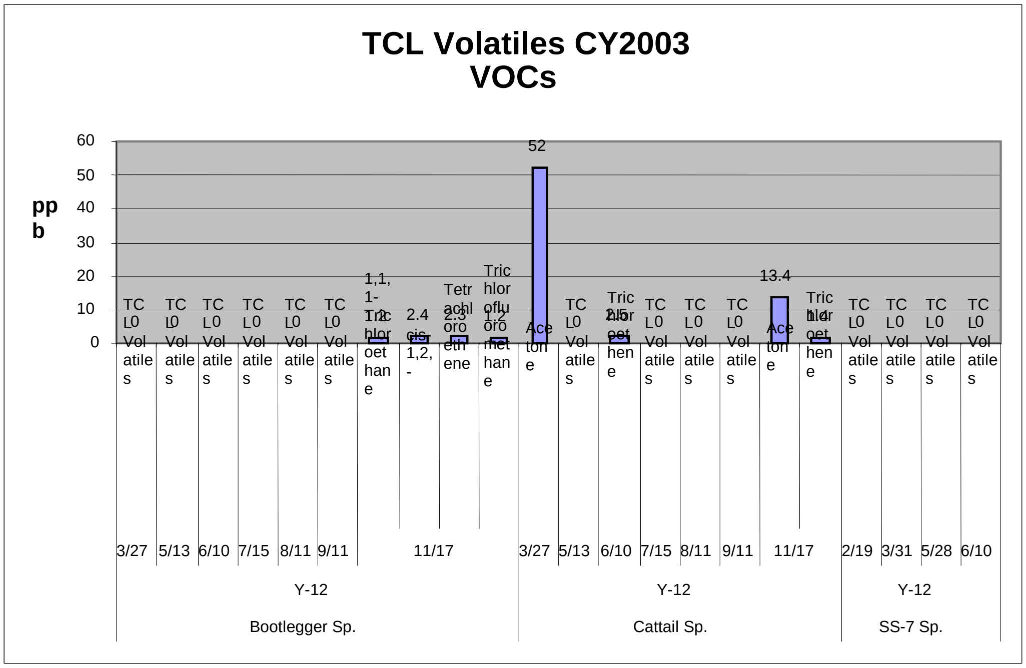



**Figure 8. Note non –detects for Bootlegger Spring until late in year.**

*Exit Pathway Springs South Campus*

Dubhe Spring at South Campus Facility is a new spring sampled with an expectation to find an overflow to Merak Spring. A large beaver pond inundates Merak Spring making sampling impracticable. Several years ago Merak Spring defined a discharge point for the South Campus Tetrachloroethene (TCE) plume. On the day Dubhe Spring was discovered an orange iron stain existed. Unfortunately, prior to sampling rains had overcome the spring's flow dispersing the staining and diluting results to below detection. Continued sampling in the South Campus Facility is expected. (See Figure 9)

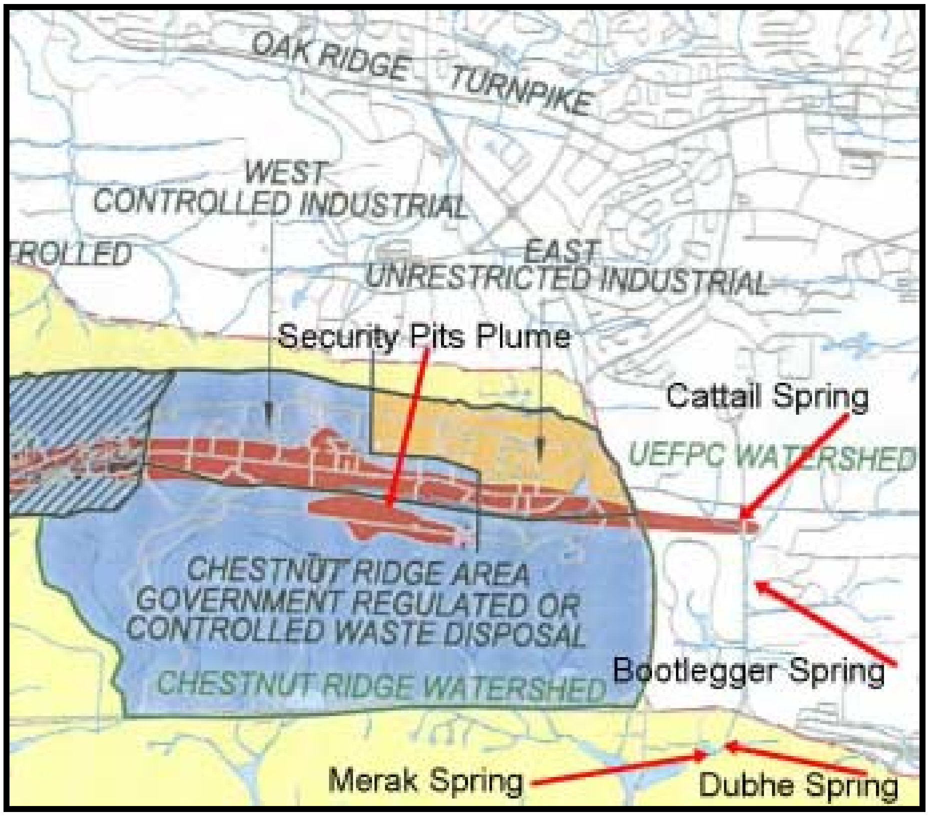



**Figure 9. Y-12 and South Campus area map. South Campus springs are at the lower part of map. Notice the absence of any plume in this area. Monitoring at South Campus shows impacts to groundwater. The Plume shown as a red or dark patch at Security Pits does not extend off-site to Bootlegger Spring.**

*Monitoring well GW-919*

One monitoring well was sampled in conjunction with the EMWMF waste cell in Bear Creek (see table 3). GW-919 is a small well that became important to high water level concerns at the waste cell. This well's artesian water levels indicated that the liner system at the waste cell was in danger of hydrostatic pressures and a lack of separation of waste form the water table. Analytical data was collected to gain background numbers and check against data being generated by the facility. Of the parameters measured only Tritium was elevated and not so much to cause concern. Difficulties with operations and design at the waste cell will require more dedicated sample devices like data loggers and automated samplers. The EMWMF is a DOE Environmental Management project for waste disposal of mostly infrastructure changes at the ORR. For additional information DOE-Oversight's Environmental Restoration program should be contacted.

**Table 3. Waste Cell Monitoring Well GW-919 September 8, 2003**

| PARAMETER | Result | Qualifier | Units | Rad Error |
|---|---|---|---|---|
| TCL Volatiles | ND | U | ppb | |
| Gross Alpha | 4.7 | | pCi/l | 3.7 |
| Gross Beta | 2.1 | | pCi/l | 2.2 |
| Pb-214 | 71.7 | | pCi/l | 5.6 |
| Bi-214 | 81.4 | | pCi/l | 6.1 |
| Tc-99 | -0.03 | | pCi/l | 0.55 |
| Tritium | 207 | | pCi/l | 102 |
| Total Alkalinity | 223 | | ppm | |
| Chloride | 3 | | ppm | |
| Dissolved Residue | 275 | | ppm | |
| NO3&NO2 Nitrogen | 0.01 | | ppm | |
| pH | 7.1 | | pH units | |
| Specific Conductivity | 450 | | umho | |
| Suspended Residue | | U | ppm | |
| Arsenic | | U | ppb | |
| Barium | | U | ppb | |
| Cadmium | | U | ppb | |
| Calcium | 63.3 | | ppm | |
| Lead | | U | ppb | |
| Magnesium | 7.5 | | ppm | |
| Mercury | | U | ppb | |
| Nickel | 13 | U | ppb | |
| Potassium | 1.2 | | ppm | |
| Selenium | | U | ppb | |
| Sodium | 18.5 | | ppm | |
| Total Chromium | 1 | | ppb | |

## Conclusions

The goal of oversight is to provide a joint assessment of surveillance and monitoring for comprehensiveness and integration. In addition, it is DOE's responsibility to provide the public with information on releases both past and present. The scope of this groundwater report does not address the joint assessment in detail. By way of an independent monitoring program a check is made of DOE performance in providing information on releases. Effective monitoring and surveillance of groundwater plumes therefore is the goal to evaluate in this report. Given the seriousness of the waste and complex hydrogeology, effectiveness becomes the key aspect. Current waste in the groundwater will remain for years, decades or even longer. In summary it is concluded from independent monitoring DOE is not effectively measuring the contaminated groundwater chiefly at the distant portion of plumes. Also, DOE should resume monitoring off-site impacts and in places where contamination is likely to migrate. Ambient sampling of some extent would too be beneficial in maintaining an off-site surveillance of condition and establishing background conditions.

It is evident plumes are not stable with respect to fate and transport and much more understanding is needed. The importance of controlled buffer areas combined with vigilant assessment of changes in the groundwater conditions is key to providing protection from exposure to waste products in the groundwater. Notices to deeds can be lost over time and water withdrawal could cause transport of waste in the groundwater. The monitoring challenge remains as long as these plumes exist. Accurate understanding of groundwater systems is needed to reduce the risk of potential groundwater exposure.

Residential wells showed no evidence of contamination. Spring sampling showed that contamination exists beyond mapped plume boundaries.

## References


DOE/OR/01-2069 & D1 *"Oak Ridge Reservation Groundwater Strategy"*

ORNL/TM-12074 *"Status Report on the Geology of the Oak Ridge Reservation."*

Rubin, P. and Peter Lemiszki, 1992. (unpublished report for MMES/DOE) *"Aspects of Oak Ridge Karst Hydrology and Geomorphology."*

Region IV EPA, May 1996. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.*

Tennessee Department of Environment and Conservation. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

TDEC DOE-O. 1996. TDEC DOE-O *Standard Operating Procedures*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

Yard, C. R. 2002. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

## Appendix

| Appendix 1 Groundwater Results | | | | | | |
|---|---|---|---|---|---|---|
| Identification | Date | Parameter group | PARAMETER | Result | Units | Rad Error |
| 21002 Sp. | 4/2/2003 | TCL Volatiles | Acetone | 14 | ppb | |
| | | | Trichloroethene | 13 | ppb | |
| | 5/28/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 6/25/2003 | TCL Volatiles | Acetone | 14 | ppb | |
| | | | Carbon Tetrachloride | 2 | ppb | |
| | 7/23/2003 | TCL Volatiles | Trichloroethene | 9.7 | ppb | |
| | 8/28/2003 | TCL Volatiles | Carbon Tetrachloride | 1.4 | ppb | |
| | | | Trichloroethene | 7.8 | ppb | |
| | 10/8/2003 | TCL Volatiles | 1,1-Dichloroethene | 1.2 | ppb | |
| 21002 Sp. Composite | 4/29/2003 | Alpha | Gross Alpha | 0 | pCi/l | 1.8 |
| | | Beta | Gross Beta | 3.3 | pCi/l | 2.4 |
| | | Gamma | Bi-214 | 30 | pCi/l | 4 |
| | | | Pb-214 | 13.6 | pCi/l | 3.4 |
| | | H-3 | Tritium | -41 | pCi/l | 96 |
| | | Tc-99 | Tc-99 | 5.85 | pCi/l | 0.81 |
| | 10/8/2003 | Alpha | Gross Alpha | -0.3 | pCi/l | 2.4 |
| | | Beta | Gross Beta | 4.6 | pCi/l | 2.4 |
| | | Gamma | Bi-214 | 40.6 | pCi/l | 4.8 |
| | | H-3 | Tritium | -38 | pCi/l | 99 |
| | | Tc-99 | Tc-99 | 5.23 | pCi/l | 0.47 |
| Bootlegger Sp. | 3/27/2003 | Alpha | Gross Alpha | 2.2 | pCi/l | 2.3 |
| | | Beta | Gross Beta | 1 | pCi/l | 2.3 |
| | | H-3 | Tritium | 20 | pCi/l | 97 |
| | | Tc-99 | Tc-99 | 1.3 | pCi/l | 0.7 |
| | | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 5/13/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 6/10/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 7/15/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 8/11/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 9/11/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 11/17/2003 | TCL Volatiles | 1,1,1-Trichloroethane | 1.2 | ppb | |
| | | | cis-1,2,-Dichloroethane | 2.4 | ppb | |
| | | | Tetrachloroethene | 2.3 | ppb | |
| | | | Trichlorofluoromethane | 1.2 | ppb | |
| Bootlegger Sp. Composite | 4/15/2003 | Alpha | Gross Alpha | 3.7 | pCi/l | 2.3 |
| | | Beta | Gross Beta | 1.2 | pCi/l | 2.3 |
| | | Gamma | Bi-214 | 40.2 | pCi/l | 4.2 |
| | | H-3 | Tritium | 30 | pCi/l | 97 |
| | | Tc-99 | Tc-99 | 0.71 | pCi/l | 0.59 |
| | 9/11/2003 | Alpha | Gross Alpha | -3.1 | pCi/l | 3 |
| | | Beta | Gross Beta | 2.2 | pCi/l | 2.2 |
| | | Gamma | Pb-214 | 22.2 | pCi/l | 4.3 |
| | | H-3 | Tritium | 129 | pCi/l | 102 |
| | | Tc-99 | Tc-99 | 0.54 | pCi/l | 0.41 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Burns Cem. | 1/28/2003 | TCL Volatiles | Acetone | 100 | ppb | |
| | 8/11/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 10/2/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| Burns Cem. Composite | 4/15/2003 | Alpha | Gross Alpha | -1.4 | pCi/l | 1.4 |
| | | Beta | Gross Beta | -0.3 | pCi/l | 1.9 |
| | | Gamma | Bi-214 | 11.5 | pCi/l | 2.8 |
| | | H-3 | Tritium | 77 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 1.07 | pCi/l | 0.6 |
| | 10/2/2003 | Alpha | Gross Alpha | -0.07 | pCi/l | 2.1 |
| | | Beta | Gross Beta | 1.7 | pCi/l | 2.1 |
| | | Gamma | Bi-214 | 78.7 | pCi/l | 5.8 |
| | | | Pb-214 | 45 | pCi/l | 4.7 |
| | | H-3 | Tritium | 3 | pCi/l | 100 |
| | | Tc-99 | Tc-99 | 0.49 | pCi/l | 0.4 |
| Cattail Sp. | 3/27/2003 | Alpha | Gross Alpha | 2.7 | pCi/l | 3 |
| | | Beta | Gross Beta | 1.6 | pCi/l | 2.3 |
| | | H-3 | Tritium | 41 | pCi/l | 97 |
| | | Tc-99 | Tc-99 | 0.96 | pCi/l | 0.57 |
| | | TCL Volatiles | Acetone | 52 | ppb | |
| | 5/13/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 6/10/2003 | TCL Volatiles | Trichloroethene | 2.5 | ppb | |
| | 7/15/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 8/11/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 9/11/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 11/17/2003 | TCL Volatiles | Acetone | 13.4 | ppb | |
| | | | Trichloroethene | 1.4 | ppb | |
| Cattail Sp. Composite | 4/15/2003 | Alpha | Gross Alpha | -0.5 | pCi/l | 3.1 |
| | | Beta | Gross Beta | 2.8 | pCi/l | 2.4 |
| | | Gamma | Bi-214 | 112 | pCi/l | 7.1 |
| | | | Pb-214 | 43 | pCi/l | 5.2 |
| | | H-3 | Tritium | 89 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 1.62 | pCi/l | 0.65 |
| | 9/11/2003 | Alpha | Gross Alpha | -4.1 | pCi/l | 3.8 |
| | | Beta | Gross Beta | 3.2 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 53.4 | pCi/l | 5.6 |
| | | | Pb-214 | 46 | pCi/l | 6.3 |
| | | H-3 | Tritium | -25 | pCi/l | 100 |
| | | Tc-99 | Tc-99 | 0.89 | pCi/l | 0.42 |
| Cattail Sp. Dup. | 5/6/2003 | Alpha | Gross Alpha | 0.9 | pCi/l | 3.3 |
| | | Beta | Gross Beta | 1.3 | pCi/l | 2.3 |
| Crooked Tree Sp. | 1/28/2003 | TCL Volatiles | Acetone | 81 | ppb | |
| | 7/15/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 10/2/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Crooked Tree Sp. Composite | 4/22/2003 | Alpha | Gross Alpha | -1.3 | pCi/l | 1.6 |
| | | Beta | Gross Beta | 0.9 | pCi/l | 2.1 |
| | | Gamma | Gamma Radionuclides | NDA | pCi/l | 0 |
| | | H-3 | Tritium | 456 | pCi/l | 104 |
| | | Tc-99 | Tc-99 | 2.21 | pCi/l | 0.65 |
| | 10/2/2003 | Alpha | Gross Alpha | -0.03 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 4 | pCi/l | 2.3 |
| | | Gamma | Bi-214 | 125.5 | pCi/l | 7.1 |
| | | | Pb-214 | 62.8 | pCi/l | 5.4 |
| | | H-3 | Tritium | 569 | pCi/l | 108 |
| | | Tc-99 | Tc-99 | 0.57 | pCi/l | 0.41 |
| Dubhe Sp. | 5/19/2003 | Alpha | Gross Alpha | -0.8 | pCi/l | 2.9 |
| | | Beta | Gross Beta | 0.7 | pCi/l | 2.1 |
| | | Gamma | Bi-214 | 55.5 | pCi/l | 7.5 |
| | | | Pb-214 | 47.1 | pCi/l | 6 |
| | | Gen Org | Chloride | 4 | ppm | |
| | | | Dissolved Residue | 239 | ppm | |
| | | | NO3&NO2 Nitrogen | 0.01 | ppm | |
| | | | pH | 7.3 | pH units | |
| | | | Specific Conductivity | 442 | umho | |
| | | | Sulfate | 11 | ppm | |
| | | | Suspended Residue | 51 | ppm | |
| | | | Total Alkalinity | 221 | ppm | |
| | | H-3 | Tritium | 162 | pCi/l | 100 |
| | | Metals | Arsenic | (blank) | ppb | |
| | | | Barium | (blank) | ppb | |
| | | | Cadmium | (blank) | ppb | |
| | | | Calcium | 69.9 | ppm | |
| | | | Lead | (blank) | ppb | |
| | | | Magnesium | 4.36 | ppm | |
| | | | Mercury | (blank) | ppb | |
| | | | Nickel | (blank) | ppb | |
| | | | Potassium | 0.55 | ppm | |
| | | | Selenium | (blank) | ppb | |
| | | | Sodium | 2 | ppm | |
| | | | Total Chromium | (blank) | ppb | |
| | | Tc-99 | Tc-99 | 0.88 | pCi/l | 0.47 |
| | | TCL Volatiles | TCL Volatiles | ND | ppb | |
| J. A. Jones Sp. | 3/13/2003 | Alpha | Gross Alpha | 13.8 | pCi/l | 5.9 |
| | | Beta | Gross Beta | 5.2 | pCi/l | 2.4 |
| | | Extractable Pet. Hydro. | Extr. Pet. Hydrocarbons | 690 | ppb | |
| | | Gamma | Bi-214 | 63.7 | pCi/l | 5.3 |
| | | | Pb-214 | 57.9 | pCi/l | 5.3 |
| | | Gen Org | Dissolved Residue | 352 | ppm | |
| | | | NO3&NO2 Nitrogen | 0.06 | ppm | |
| | | | pH | 7.6 | pH units | |
| | | | Specific Conductivity | 551 | umho | |
| | | | Suspended Residue | 25 | ppm | |
| | | | Total Alkalinity | 245 | ppm | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | GRO | GRO | 120 | ppb | |
| | | Metals | Arsenic | (blank) | ppb | |
| | | | Cadmium | (blank) | ppb | |
| | | | Copper | 3 | ppb | |
| | | | Iron | 6450 | ppb | |
| | | | Lead | (blank) | ppb | |
| | | | Mercury | (blank) | ppb | |
| | | | Nickel | (blank) | ppb | |
| | | | Selenium | (blank) | ppb | |
| | | | Thallium | (blank) | ppb | |
| | | | Total Chromium | (blank) | ppb | |
| | | | Zinc | 610 | ppb | |
| | | Tc-99 | Tc-99 | 0.89 | pCi/l | 0.55 |
| | | TCL Volatiles | Acetone | 38 | ppb | |
| | | | cis-1,2-Dichloroethene | 147 | ppb | |
| | | | Trichloroethene | 21 | ppb | |
| | | | Vinyl Chloride | 6 | ppb | |
| NTS Seep | 2/5/2003 | Alpha | Gross Alpha | 7.4 | pCi/l | 5.9 |
| | | Beta | Gross Beta | 5.6 | pCi/l | 2.4 |
| | | Gamma | Bi-214 | 113.9 | pCi/l | 6.7 |
| | | | Pb-214 | 67.1 | pCi/l | 5.6 |
| | | | Tl-208 | 7.2 | pCi/l | 2.1 |
| | | H-3 | Tritium | 50 | pCi/l | 92 |
| | | Tc-99 | Tc-99 | 7.36 | pCi/l | 0.62 |
| | | TCL Volatiles | Trichloroethene | 28 | ppb | |
| PCO Seep | 3/25/2003 | TCL Volatiles | Trichloroethene | 27 | ppb | |
| Raccoon Creek Sp. | 1/28/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 7/15/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 8/19/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 10/2/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| Raccoon Creek Sp. Composite | 4/22/2003 | Alpha | Gross Alpha | -2 | pCi/l | 4.3 |
| | | Beta | Gross Beta | 15.7 | pCi/l | 3 |
| | | Gamma | Bi-214 | 47.6 | pCi/l | 5.3 |
| | | | Pb-214 | 20.6 | pCi/l | 3.6 |
| | | H-3 | Tritium | 140 | pCi/l | 99 |
| | | Tc-99 | Tc-99 | 2.14 | pCi/l | 0.56 |
| | 10/2/2003 | Alpha | Gross Alpha | -4.1 | pCi/l | 6 |
| | | Beta | Gross Beta | 45.6 | pCi/l | 4.2 |
| | | Gamma | Bi-214 | 41 | pCi/l | 4.5 |
| | | | Pb-214 | 29 | pCi/l | 4.1 |
| | | H-3 | Tritium | 262 | pCi/l | 104 |
| | | Tc-99 | Tc-99 | 0.53 | pCi/l | 0.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SNS-1 Sp. Composite | 4/22/2003 | Alpha | Gross Alpha | -1.3 | pCi/l | 2.1 |
| | | Beta | Gross Beta | 1.6 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 65.3 | pCi/l | 5.7 |
| | | | Pb-214 | 42.2 | pCi/l | 4.7 |
| | | H-3 | Tritium | 96 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 0.62 | pCi/l | 0.54 |
| | 9/24/2003 | Alpha | Gross Alpha | -1.3 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 0.3 | pCi/l | 2 |
| | | Gamma | Bi-214 | 53.6 | pCi/l | 5.1 |
| | | | Pb-214 | 22.5 | pCi/l | 4 |
| | | H-3 | Tritium | 103 | pCi/l | 102 |
| | | Tc-99 | Tc-99 | 0.17 | pCi/l | 0.4 |
| SNS-4 Sp. Composite | 4/15/2003 | Alpha | Gross Alpha | -0.2 | pCi/l | 2.2 |
| | | Beta | Gross Beta | 1.9 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 48.3 | pCi/l | 5.4 |
| | | | Pb-214 | 42.6 | pCi/l | 6.9 |
| | | H-3 | Tritium | 96 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 0.39 | pCi/l | 0.58 |
| | 9/24/2003 | Alpha | Gross Alpha | -1.4 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 2.3 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 87.8 | pCi/l | 6.5 |
| | | | Pb-214 | 47 | pCi/l | 5 |
| | | H-3 | Tritium | 71 | pCi/l | 101 |
| | | Tc-99 | Tc-99 | 0.16 | pCi/l | 0.39 |
| SNS-4 Sp. Dup. Composite | 4/15/2003 | Alpha | Gross Alpha | -1.2 | pCi/l | 1.9 |
| | | Beta | Gross Beta | 1.9 | pCi/l | 2.2 |
| | 9/24/2003 | Alpha | Gross Alpha | -0.6 | pCi/l | 2.7 |
| | | Beta | Gross Beta | 2.2 | pCi/l | 2.2 |
| SNS-6 Sp. Composite | 4/15/2003 | Alpha | Gross Alpha | -0.2 | pCi/l | 2.2 |
| | | Beta | Gross Beta | 1.9 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 48.3 | pCi/l | 5.4 |
| | | | Pb-214 | 42.6 | pCi/l | 6.9 |
| | | H-3 | Tritium | 96 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 0.39 | pCi/l | 0.58 |
| | 4/22/2003 | Alpha | Gross Alpha | -1.6 | pCi/l | 2 |
| | | Beta | Gross Beta | 0.1 | pCi/l | 2.1 |
| | | Gamma | Gamma Radionuclides | NDA | pCi/l | 0 |
| | | H-3 | Tritium | 49 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 0.41 | pCi/l | 0.53 |
| | 9/24/2003 | Alpha | Gross Alpha | -3.2 | pCi/l | 2.5 |
| | | Beta | Gross Beta | 2.4 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 62.8 | (blank) | 5.7 |
| | | | Pb-214 | 34.8 | pCi/l | 4.8 |
| | | H-3 | Tritium | 66 | pCi/l | 101 |
| | | Tc-99 | Tc-99 | 0.51 | pCi/l | 0.4 |
| SNS-6 Sp. Dup. Composite | 9/24/2003 | Alpha | Gross Alpha | 0.7 | pCi/l | 3.2 |
| | | Beta | Gross Beta | 2.2 | pCi/l | 2.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SS-7 Sp. | 1/21/2003 | Gen Org | NO3&NO2 Nitrogen | 1.35 | ppm | |
| | 2/19/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 3/31/2003 | Gen Org | NO3&NO2 Nitrogen | 0.16 | ppm | |
| | | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 5/28/2003 | Gen Org | NO3&NO2 Nitrogen | 0.08 | ppm | |
| | | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 6/10/2003 | Gen Org | NO3&NO2 Nitrogen | 0.32 | ppm | |
| | | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 7/7/2003 | Alpha | Gross Alpha | -1 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 2.9 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 161 | pCi/l | 11 |
| | | | Pb-214 | 113 | pCi/l | 13 |
| | | H-3 | Tritium | -14 | pCi/l | 100 |
| | | Tc-99 | Tc-99 | 1.27 | pCi/l | 0.62 |
| SS-7 Sp. Composite | 3/31/2003 | Alpha | Gross Alpha | 2.7 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 0.4 | pCi/l | 2.3 |
| | | Gamma | Bi-214 | 45.6 | pCi/l | 5.8 |
| | | | Pb-214 | 17.3 | pCi/l | 3.5 |
| | | H-3 | Tritium | 53 | pCi/l | 98 |
| | | Tc-99 | Tc-99 | 3.3 | pCi/l | 0.67 |
| USGS 10895 | 4/29/2003 | Alpha | Gross Alpha | 0.6 | pCi/l | 2 |
| | | Beta | Gross Beta | 0.3 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 70.4 | pCi/l | 5.9 |
| | | | Pb-214 | 42.8 | pCi/l | 4.6 |
| | | H-3 | Tritium | 38 | pCi/l | 97 |
| | | Tc-99 | Tc-99 | 1.14 | pCi/l | 0.71 |
| | 7/23/2003 | TCL Volatiles | TCL Volatiles | ND | ppb | |
| | 8/30/2003 | TCL Volatiles | Trichloroethene | 2.5 | ppb | |
| | 9/11/2003 | TCL Volatiles | Trichloroethene | 4.4 | ppb | |
| USGS 10895 Composite | 9/11/2003 | Alpha | Gross Alpha | -2.2 | pCi/l | 2.6 |
| | | Beta | Gross Beta | 2 | pCi/l | 2.2 |
| | | Gamma | Bi-214 | 37.4 | pCi/l | 4.6 |
| | | | Pb-214 | 30.3 | pCi/l | 4.5 |
| | | H-3 | Tritium | 36 | pCi/l | 101 |
| | | Tc-99 | Tc-99 | 0.59 | pCi/l | 0.4 |

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Ambient Radiation Monitoring on the Oak Ridge Reservation Using Environmental Dosimetry

Principal Authors: Gary Riner, Howard Crabtree

**Abstract**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) began monitoring ambient radiation levels on the Oak Ridge Reservation in 1995. The program provides estimates of the dose to members of the public from exposure to gamma and neutron radiation attributable to Department of Energy activities on the reservation and baseline values for measuring the need and effectiveness of remedial activities. In this effort, environmental dosimeters have been placed at selected locations on and near the reservation. Results from the dosimeters are compared to background values and the state dose limit for members of the public. While all the doses reported for 2003 at off-site locations were below the dose limit for members of the public, several locations that are considered to be potentially accessible to the public had results in excess of the limit. As in the past, doses above 100 mrem were associated with various sites located in access-restricted areas of the reservation.

**Introduction**

Radiation is emitted by various radionuclides that have been produced, stored, and disposed of on the Oak Ridge Reservation (ORR). Associated contaminants are evident in ORR facilities and surrounding soils, sediments, and waters. In order to assess the risks posed by these contaminants, the division began monitoring ambient radiation levels on and in the vicinity of the ORR in 1995. This program provides:

- Conservative estimates of the potential dose to members of the public from exposure to gamma radiation;
- Baseline values used to assess the need and effectiveness of remedial actions;
- Information necessary to establish trends in gamma radiation emissions;
- Information relative to the unplanned release of radioactive contaminants on the ORR.

In this effort, environmental dosimeters were used to measure the external radiation dose attributable to radiation at selected monitoring stations. Associated data was compared to background values and the state's primary dose limit for members of the public (100 mrem/year).

**Methods and Materials**

The dosimeters used in the program were obtained from Landauer, Inc., Glenwood, Illinois. Each dosimeter used an aluminum oxide photon detector to measure the dose from gamma radiation (minimum reporting value = 1 mrem). At locations where there was a potential for the release of neutron radiation, the dosimeters also contained an allyl diglycol carbonate based neutron detector (minimum reporting value = 10 mrem). Dosimeters that contained the photon detectors alone were collected quarterly and sent to Landauer for processing. Dosimeters that contained both photon and neutron detectors were collected and processed semi-annually (to allow more precise neutron measurements). To account for exposures that could have been received in transit or storage, control dosimeters of both types were provided with each shipment from the Landauer Company.

The control dosimeters were stored at the division's office and returned to Landauer with the associated field-deployed dosimeters for processing. Any dose reported for the control dosimeters was subtracted from the results for the field-deployed dosimeters prior to being reported.

Monitoring stations in the program included operating facilities; locations on the ORR that are potentially accessible to the public; local communities; and sites subject to or undergoing remediation. The approximate locations of the monitoring sites are depicted in Figure A1 in the appendix, along with the annual dose for each site.

Division staff prepared a report of the data once the quarterly results were received and provided this report to DOE, DOE contractors, and other interested parties. At the end of the year, the quarterly results were summed for each location and the resultant annual doses compared to background values and the state's primary dose limit for members of the public (100 mrem/year). Associated data is presented in the attached appendix (Table A1).

## Results and Discussion

The dose of radiation received at any given location is dependent on the intensity and the duration of the exposure. For example, an individual standing at a site where the dose rate is 1 mrem/hr would receive a dose of 2 mrem, if he stayed at the same spot for 2 hours. If he were exposed to the same level of radiation for 8 hours a day for the approximately 220 working days in a year (1,760 hours), he would receive a dose of 1,760 mrem in that year. It should be understood, the doses reported in the division's Ambient Radiation Monitoring Program are based on the exposure an individual would receive if he remained at the monitoring station 24 hours a day for a year (8,760 hours). Since this is very unlikely to be the actual case, the doses reported should be viewed as conservative estimates of the maximum dose an individual would receive at each location.

In the past, the division relied on the measurement of gamma radiation to estimate the radiation doses at the various monitoring stations. While gamma radiation is expected to be the major contributor to external exposures, an additional dose from neutrons was anticipated at sites near the uranium hexafluoride cylinder storage yards located at the East Tennessee Technology Park (ETTP) and burial grounds at the Oak Ridge National Laboratory (ORNL). In 2000, staff began placing neutron dosimeters at monitoring stations where the presence of neutron radiation was a possibility. Results from these dosimeters have been somewhat erratic, but indicative of a measurable neutron flux at several of the locations. Where a neutron dose was reported in the data, it has been incorporated into the total dose reported in Table A1.

The monitoring locations and associated results for the program can be roughly organized into three categories: (1) stations located off the ORR; (2) sites on the ORR that are to some degree accessible to the public; and (3) locations within access-controlled areas of the reservation.

### Stations off the ORR

The doses reported for monitoring stations off the reservation (e.g., residential areas) were all well below the 100 mrem dose limit for members of the public and to a large degree below the detection capabilities of the environmental dosimeters (1 mrem).

Stations Potentially Accessible to the Public

Since access to the reservation has been predominately restricted to employees of DOE or their contractors in the past, locations within the fenced areas of the reservation have traditionally been considered inaccessible to the general public. With the reindustrialization of portions of the reservation, there has been an influx of workers employed by businesses not directly associated with DOE operations. If these individuals are considered members of the general public, several of the sites within the boundaries of the ORR become problematic. For example, relatively high doses of radiation were measured at ETTP in the vicinity of the K-1420 Building (802 mrem) and the uranium hexafluoride cylinder storage yards (1,889 mrem). Under current conditions, these sites are potentially accessible to workers not employed by DOE or their contractors.

In 2003, dose measurements taken in the vicinity of the cylinder yards ranged from 155 to 1,889 mrem. Two of these locations, Stations 12 (194 mrem) and Station 51 (1,357 mrem), are located on the fence that separates the K-1066-E uranium hexafluoride cylinder storage yard from the Poplar Creek area, making it accessible from outside the facility boundary. Due to the deteriorating condition of the cylinders (six have leaked) and elevated dose measurements characteristic of the storage yards, the division implemented a separate monitoring project in 1999 designed to gather more comprehensive data from the cylinder yards. Associated information can be found elsewhere in this report under the heading *Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride ($UF_6$) Cylinder Yards at ETTP*.

Stations within Access Controlled Areas of the Reservation

While conditions could change, other sites monitored that reported results appreciably above the primary dose limit are located within access controlled areas of the reservation. These sites are subject to remediation in accordance with the provisions of CERCLA and the Federal Facility Agreement (FFA) for the ORR. While it is beyond the scope of this report to address each of these sites individually, several merit comment.

*The Cesium Forrest [Station 32 (15,325 mrem)]*: The highest dose reported for 2003, 15,325 mrem, was from a dosimeter that has been placed on a tulip poplar tree (Station 32) in ORNL's Cesium Forest. In 1962, a group of trees at this location were injected with a total of 360 millicuries of cesium-137, as part of a study on the isotope's behavior in a forest ecosystem (Witkamp, 1964). Based on the dosimetry results, it appears a significant amount of the cesium remains in the trees and local environment. In 2003, the quarterly dose at the location more than doubled (2,145 mrem to 4,753 mrem) after the dosimeter was repositioned on the tree in the third quarter. The annual dose increased from 10,136 mrem in 2002 to 15,325 mrem in 2003.

*The 3513 Waste Holding Basin [Station 30 (1358 mrem)]:* Until 1977, the 3513 Waste Holding Basin served as a settling pond for ORNL effluents prior to their release to White Oak Creek. Sludge from the bottom of the basin was estimated to contain over 200 curies of cesium-137, along with various other radionuclides including transuranics (Bechtel, 1992). In 1997, a CERCLA Record of Decision provided for the removal and disposal of sludge in the 3513 Basin and the adjacent 3524 Equalization Basin (which also received process wastes historically). In 2001, DOE contractors began removing the sludge from the 3513 Basin, which continued into 2003 when the pond was filled and capped. In 2001, the dose reported at Station 30 (which is near the 3513 basin) was 2,328 mrem/yr. The dose reported in 2003 was 1,358 mrem/yr, but the results for the last quarter of 2003 dropped to 45 mrem after equipment associated with the remediation was removed from the location.

*The North Tank Farm [Station 41(258 mrem)]* The North Tank Farm is located near the center of ORNL's main campus. In the past, a number of underground storage tanks were emplaced at this location to store and/or treat radioactive and hazardous wastes. In the late 1990s, one of these tanks, W-1A, was discovered to be the source of the Corehole 8 groundwater plume, which covers a large area adjacent and to the west of the site. Contaminants associated with this plume include strontium-90, americium-241, plutonium-238, 239, 240, and curium-244 (Bechtel, 1992). These contaminants discharge to First Creek and are transported to White Oak Creek and beyond.

In 1998, DOE proposed to remove W-1A and the adjacent soils, which had developed into a secondary source of the contaminants feeding the plume. The removal action began in 2001 but was suspended and the excavation covered after radioactivity was encountered at levels much higher than the remedial contractor had anticipated. Prior to the beginning of the removal action, dose measurements fluctuated around 100 mrem at Station 41, which is located next to a sidewalk adjacent to the site. In 2001, when the action began, the dose reported for the year was 463 mrem. Despite the suspension of the project in 2001, the dose for 2002 rose to 540 mrem (probably because equipment was removed that had been shielding the dosimeter). The dose reported for Station 41 in 2003 was 258 mrem, but the levels had decreased during the year from 118 mrem reported for the first quarter to 31 mem reported for the last quarter.

*The ORNL Coal Yard Environmental Restoration Storage Area [Stations 88 and 89]*
As previously noted, sludge excavated from the 3513 Waste Holding Basin and the 3524 Equalization Basin contained high levels of cesium-137, along with various other radionuclides including transuranics (Bechtel, 1992). Consequently, the sludge exhibited high levels of radioactivity. While in the basins, this radioactivity was attenuated by the water above it, reducing the exposure levels at the surface. Once removed from this shielding, the exposure levels associated with the sludge substantially increased. As part of the remedial action, the sludge taken from the basins was mixed with cement, formed into large concrete monoliths, and stored in locations across the ORNL campus.

To access the hazards associated with the sludge, staff placed a continuous exposure rate monitor at the boundary of a radiation control area surrounding sludge monoliths at the Environmental Restoration Coal Yard Storage Area. The measurements taken in December 2002 with the exposure rate monitor averaged 1,740 μR/hr. The state's dose limit for unrestricted areas is 2 mem in any one-hour period, which would be equivalent to an exposure to gamma radiation of 2,000 μR. As a consequence, the exposure rate monitor was left at the location, along with one of the environmental dosimeters. Even though the monoliths were moved during the monitoring period, the dose (2,388 mrem) was the highest reported for the quarter. In the absence of the monoliths, the dose at the site fell to 16 mrem the following quarter.

After the removal of the monoliths, the radiation area at the coal yard was reduced to the size necessary to surround materials that had been contaminated at the Corehole 8 Remedial Action.

The dosimeter was placed near the new boundary for this radiation area in October 2003. The dose reported for the quarter was 2,669 mrem. The second highest measurement reported (the tree in the Cesium Forest was the highest).

*The Old Hydrofracture Facility (OHF) Surface Impoundment [Station 56 (828 mrem)]:* From 1964 to 1980 radioactive wastes were transported through pipelines from the ORNL main complex to the Old Hydrofracture Facility, which is located in Melton Valley, east of Solid Waste Management Unit (SWSA) 5 South. Underground storage tanks at the OHF held this waste prior to it being mixed with grout and injected into the bedrock (approximately 1,000 feet beneath the ground surface). During this process, the tanks and the OHF surface impoundment (constructed to retain spills/overflow) were contaminated with fission products, activation products, and transuranic radionuclides. In this regard, the OHF pond exhibited some of the highest gamma emissions measured in the SWSA 5 area (DOE, 1998a). In 2000, contaminated sediments in the pond were grouted in place and the basin was filled and capped. The action did not remove the contaminants (as originally planned) but the cover shields radiation being emitted by the radionuclides contained in the sediments. As a consequence, the dose measured at Station 56 has gone down from the 3,612 mrem reported in 2000 to 828 mrem measured in 2003.

**Conclusion**

The monitoring of radiation using environmental dosimeters has proven to be a relatively economic and effective method of estimating ambient gamma radiation levels on and in the vicinity of the ORR. Doses reported for 2003 at off-site locations were all below the state limit for members of the public. Several locations on the reservation that are considered potentially accessible to the public exhibited results in excess of the primary dose limit. These sites are primarily associated with uranium hexafluoride cylinder storage yards at ETTP, where DOE's reindustrialization initiative has resulted in an influx of workers not directly related to DOE operations. As in the past, various sites located in restricted areas of the reservation exhibited annual doses in excess of the primary dose limit. These sites are subject to remediation in accordance with provisions specified in CERCLA and the FFA. Decreases in the doses reported at several of these locations can be attributed to associated remedial activities.

**References**

Bechtel. 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR-1043/V1&D1. September 1992.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 2000. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2001.* Oak Ridge, Tennessee.

U.S. Department of Energy. 1998. *Engineering Evaluation/Cost Analysis for the Old Hydrofracture Facility Tanks and Impoundment, Oak Ridge National Laboratory, Oak Ridge, Tennessee.* DOE/OR/02-1706&D1.

U.S. Department of Energy. 1999. *1999 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge Tennessee*. DOE/OR-1790&D1.

Witkamp M., and M.L. Frank. 1964. *First Year of Movement, Distribution and Availability of $Cs^{137}$ in the Forest Floor under Tagged Tulip Poplars*. *Radiation Botany*, Vol. 4 pp. 485-495.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

**APPENDIX: LOCATION MAP AND TABLE OF RESULTS FROM TDEC MONITORING ON THE OAK RIDGE RESERVATION USING ENVIRONMENTAL DOSIMETERS**

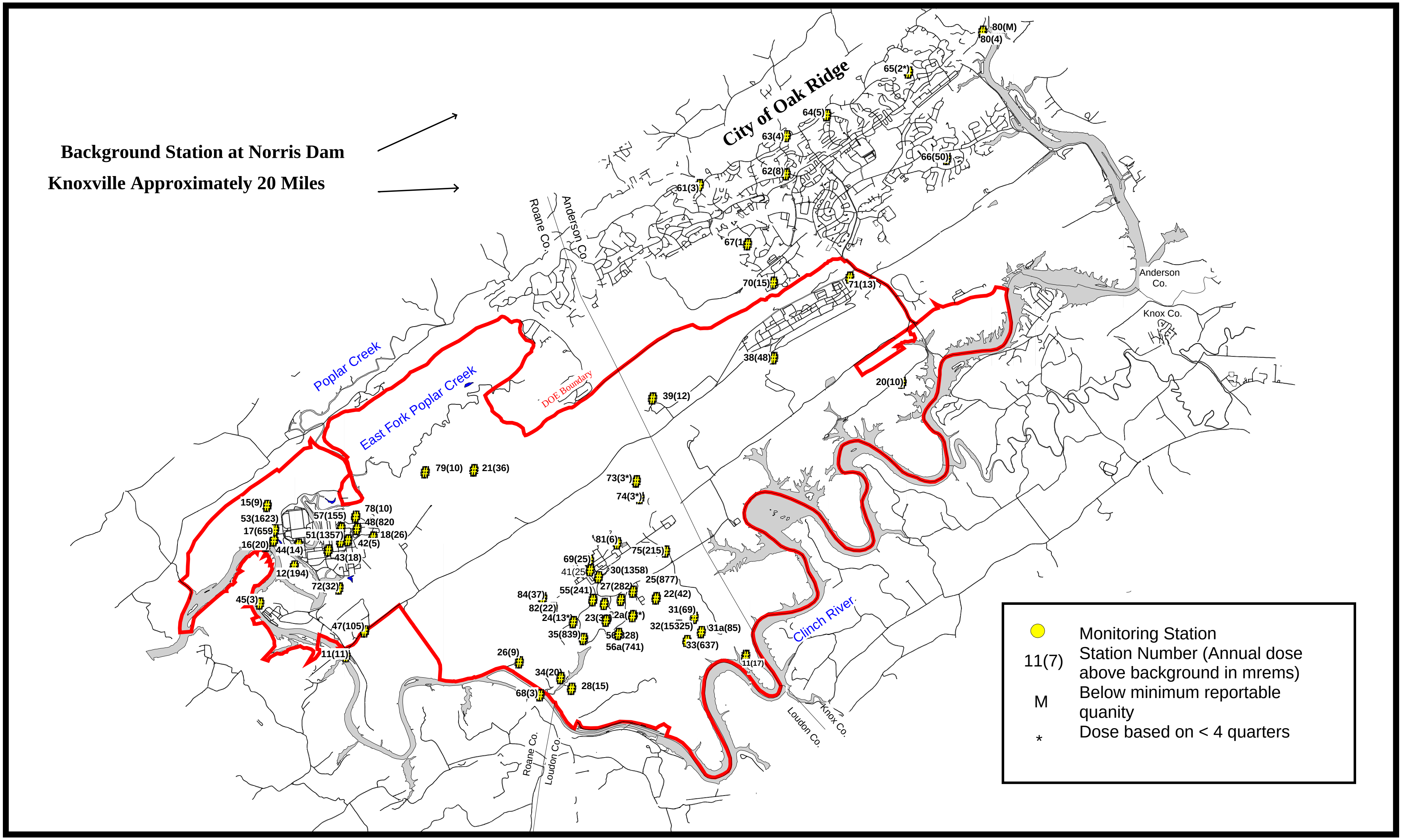

**Figure A1: Approximate Location TDEC Environmental Dosimeters on the Oak Ridge Reservation**

**Table A1: 2003 Results from TDEC monitoring on the Oak Ridge Reservation using Environmental Dosimeters**

| Station # (Dosimeter) | Location *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly* | Type of Radiation | Dose Reported for 2003 in mrems *M = Below Minimum Reportable Quantity* | | | | Total Dose for 2003 | Total for 2002 |
|---|---|---|---|---|---|---|---|---|
| | | | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | | |
| 9. (OSL) | Off-site Norris Dam Air Monitoring Station (Background) | Gamma | M | M | M | 7 | 7 | M |
| 11. (OSL) | ETTP Grassy Creek Embayment on the Clinch River | Gamma | 1 | M | M | 10 | 11 | M* |
| 12. (Neutron) | ETTP $UF_6$ Cylinder Storage Yard K-1066-E | Neutron | | M | M | | 194 | 447 |
| | | Gamma | 75 | | 119 | | | |
| 15. (OSL) | ETTP K-1070-A Burial Ground | Gamma | M | M | M | 9 | 9 | 8 |
| 16. (OSL) | ETTP K-901 Pond | Gamma | 6 | 7 | M | 7 | 20 | 2 |
| 17. (Neutron) | ETTP K-1066-K $UF_6$ Cylinder Yard (near K-895) | Neutron | 20 | | M | | 659 | 738 |
| | | Gamma | 299 | | 340 | | | |
| 18. (OSL) | ETTP TSCA on fence across from Tank Farm | Gamma | 4 | 10 | 2 | 10 | 26 | 14 |
| 20. (OSL) | ORNL Freels Bend Entrance | Gamma | M | 2 | 3 | 5 | 10 | 2 |
| 21. (OSL) | ETTP White Wing Scrap Yard | Gamma | 9 | 8 | 7 | 12 | 36 | 19 |
| 22. (OSL) | ORNL High Flux Isotope Reactor | Gamma | 7 | 11 | 5 | 19 | 42 | 15 |
| 22a. (OSL) | ORNL High Flux Isotope Reactor (duplicate) | Gamma | 6 | 6 | 6 | LOST | 18* | 24 |
| 23. (OSL) | ORNL Solid Waste Storage Area 5 | Gamma | 5 | 5 | 5 | 15 | 30 | 17 |
| 24. (OSL) | ORNL Building X-7819 | Gamma | LOST | 7 | 6 | LOST | 13* | 33 |
| 25. (OSL) | ORNL Molten Salt Reactor Experiment | Gamma | 181 | 226 | 251 | 219 | 877 | 694 |
| 26. (OSL) | ORNL Cesium Fields | Gamma | M | 3 | 2 | 4 | 9 | M |
| 27. (OSL) | ORNL White Oak Creek Weir @ Lagoon Rd | Gamma | 55 | 68 | 87 | 72 | 282 | 168* |
| 28. (OSL) | ORNL White Oak Dam | Gamma | M | 6 | M | 9 | 15 | M |
| 30. (OSL) | ORNL X-3513 Impoundment | Gamma | 253 | 833 | 227 | 45 | 1,358 | 873 |
| 31. (OSL) | ORNL @ Cesium Forest boundary | Gamma | 15 | 19 | 11 | 24 | 69 | 58 |
| 31a. (OSL) | ORNL @ Cesium Forest boundary (duplicate) | Gamma | 18 | 24 | 18 | 25 | 85 | 64 |
| 32. (OSL) | ORNL Cesium Forest on tree | Gamma | 2,560 | 2,145 | 4753** | 5867** | 15325** | 10,136 |
| 33. (OSL) | ORNL Cesium Forest Satellite Plot | Gamma | 185 | 140 | 148 | 164 | 637 | 571 |
| 34. (OSL) | ORNL SWSA 6 on fence @ Highway 95 | Gamma | 1 | 9 | 4 | 6 | 20 | 8 |
| 35. (OSL) | ORNL confluence of White Oak Creek & Melton Branch | Gamma | 216 | 188 | 239 | 196 | 839 | 904 |
| 38. (OSL) | Y-12 Uranium Oxide Storage Vaults | Gamma | 8 | 13 | 11 | 16 | 48 | 34 |
| 39. (OSL) | Y-12 @ back side of Walk In Pits | Gamma | 3 | M | M | 9 | 12 | 2 |
| 41. (OSL) | ORNL North Tank Farm | Gamma | 118 | 80 | 29 | 31 | 258 | 540 |
| 42. (OSL) | ETTP east side of the K-1401 Building | Gamma | M | M | M | 5 | 5 | 2 |
| 43. (OSL) | ETTP west side of the K-1401 Building | Gamma | 4 | 4 | M | 10 | 18 | 11 |
| 44. (OSL) | ETTP K-25 Building | Gamma | 6 | M | M | 8 | 14 | 10 |
| 45. (OSL) | ETTP K-770 Scrap Yard | Gamma | M | 3 | M | M | 3 | M |
| 46. (OSL) | ORNL Homogeneous Reactor Experiment Site | Gamma | 69 | 90 | 126 | 105 | 390 | 308 |
| 47. (OSL) | Y-12 Bear Creek Road ~ 2800 feet from Clinch River | Gamma | 17 | 28 | 28 | 32 | 105 | 120 |
| 48. (OSL) | ETTP K-1420 Building | Gamma | 157 | 164 | 224 | 257 | 802 | 870 |
| 51. (Neutron) | ETTP north side of the K-1066-E $UF_6$ Cylinder Storage Yard | Neutron | M | | 30 | | 1,357 | 1,551 |
| | | Gamma | 593 | | 734 | | | |
| 53. (Neutron) | ETTP southwest corner of the K-1066-K $UF_6$ Cylinder Storage Yard | Neutron | M | | M | | 1,889 | 2,219 |
| | | Gamma | 1,145 | | 744 | | | |
| 53a. (Neutron) | ETTP southwest corner of the K-1066-K $UF_6$ Cylinder Storage Yard (duplicate) | Neutron | 50 | | M | | 1,623 | 1,896 |
| | | Gamma | 829 | | 744 | | | |
| 55. (OSL) | ORNL SWSA 5 True Waste Trench | Gamma | 102 | 78 | 28 | 33 | 241 | 507 |

**Table A1: 2003 Result from TDEC monitoring on the ORR using Environmental Dosimeters (Continued)**

| **Station # (Dosimeter)** | **Location** *Optically Stimulated Luminescent Dosimeter (OSLs) are reported quarterly* | **Type of Radiation** | **Dose Reported for 2003 in mrems** *M = Below Minimum Reportable Quantity* | | | | **Total for 2003** | **Total for 2002** |
|---|---|---|---|---|---|---|---|---|
| | | | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | | |
| 56. (OSL) | ORNL Old Hydrofracture Pond | Gamma | 216 | 184 | 237 | 191 | 828 | 1,046 |
| 56a. (Neutron) | ORNL Old Hydrofracture Pond (duplicate) | Neutron | M | | M | | 781 | 1,133 |
| | | Gamma | 383 | | 398 | | | |
| 57. (OSL) | ETTP $UF_6$ Cylinder Storage Yard K-1066-B | Gamma | 31 | 36 | 36 | 52 | 155 | 128 |
| 61. (OSL) | Off site Temp. #14 Outer & Illinois Ave | Gamma | M | M | M | 3 | 3 | M |
| 62. (OSL) | Off site Temp. #15 East Pawley | Gamma | M | 3 | M | 5 | 8 | 1 |
| 63. (OSL) | Off site Temp. #16 Key Springs Road | Gamma | M | M | M | 4 | 4 | M |
| 64. (OSL) | Off site Temp. #17 Cedar Hill Greenway | Gamma | M | M | M | 5 | 5 | M |
| 65. (OSL) | Off site Temp. #18 California Ave. | Gamma | M | M | LOST | 2 | 2* | M |
| 66. (OSL) | Off site Temp. #19 Emory Valley Greenway | Gamma | 10 | 11 | 10 | 19 | 50 | 28 |
| 67. (OSL) | Off site Temp. #20 West Vanderbilt | Gamma | 3 | 2 | M | 9 | 14 | 9 |
| 68. (OSL) | ORNL White Oak Creek @ Coffer Dam | Gamma | M | M | M | 3 | 3 | M |
| 69. (OSL) | ORNL Graphite Reactor | Gamma | 3 | 7 | 6 | 9 | 25 | 26 |
| 70. (OSL) | Off site Scarboro Perimeter Air Monitoring Station | Gamma | M | 3 | 2 | 10 | 15 | M |
| 71. (OSL) | Y-12 East Perimeter Air Monitoring Station | Gamma | M | M | M | 13 | 13 | 1 |
| 72. (OSL) | ETTP Visitors Center | Gamma | 8 | 8 | 4 | 12 | **32** | **10** |
| 73. (OSL) | ORNL Temp. #3: Spallation Neutron Source (north side) | Gamma | LOST | M | M | 3 | 3* | M |
| 74. (OSL) | ORNL Temp. #4: Spallation Neutron Source (south side) | Gamma | M | LOST | M | 3 | 3* | M* |
| 75. (OSL) | ORNL Temp #5: hot spot on Haw Ridge | Gamma | 45 | 55 | 60 | 55 | 215 | 209 |
| 78. (OSL) | ETTP Temp. #11: ED3 Quarry at Blair Road | Gamma | M | 5 | M | 5 | 10 | 3 |
| 79. (OSL) | ETTP Temp. #12: ED1 on pole | Gamma | M | M | M | 10 | 10 | 7* |
| 80. (OSL) | Off site Temp. #13: Elza Gate | Gamma | M | M | M | 4 | 4 | 1 |
| 81. (OSL) | ORNL visitors center | Gamma | M | 1 | M | 5 | 6 | 2 |
| 82. (OSL) | ORNL Wag 3 | Gamma | 17 | 1 | M | 4 | 22 | 512 |
| 84. (OSL) | ORNL Temp. #2 Wag 3 | Gamma | 21 | 5 | 5 | 6 | 37 | 68 |
| 86. (OSL) | Off site Loudoun Dam Air Monitoring Station (Background) | Gamma | M | M | M | 5 | 5 | 2 |
| 86a. (Neutron) | Off site Loudoun Dam Air Monitoring Station (Background) | Neutron | M | | M | | 8 | 8 |
| | | Gamma | M | | 8 | | | |
| 87. (Neutron) | ORNL SWSA 5 | Neutron | 20 | | 30 | | 341 | New |
| | | Gamma | 71 | | 220 | | | |
| 88 (OSL) | ORNL Coal Yard Storage Area (SIOU Sediments). | Gamma | New | 2,388 | 16 | Discontinued | 2,404* | New |
| 89 (OSL) | ORNL Coal Yard Storage Area (Core Hole 8 material). | Gamma | New | New | New | 2,669 | 2,669* | New |

Notes: Two types of dosimeters are used in the program, optically stimulated luminescent dosimeters (OSLs) and neutron dosimeters. The OSLs measure the dose from gamma radiation, which is considered sufficient for most of the monitoring stations. The neutron dosimeters, which have been placed at selected locations, measure the dose from neutrons in addition to the gamma radiation. At the locations where the neutron dosimeters have been deployed the total dose is the sum of the doses reported for neutrons and gamma radiation.

The primary dose limit for members of the public specified in both DOE Orders and 10 CFR Part 20 (Standards for Protection Against Radiation) is 100 mrem total effective dose equivalent exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division office and returned to the vender for processing along with the associated field-deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field-deployed dosimeters.

M = Below minimum reportable quantity. * = The dose reported for this station was based on the sum of less than four quarters of data. ** #32 Cesium Forest on Tree was repositioned at the beginning of the third quarter 2003 resulting in increased readings.

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Ambient Gamma Radiation Monitoring of the Uranium Hexafluoride ($UF_6$) Cylinder Yards at the East Tennessee Technology Park.

Principle Author: Robert Storms

**Abstract**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) in cooperation with the Department of Energy (DOE) and the Bechtel Jacobs Company is conducting a radiation dose rate survey of the East Tennessee Technology Park's (ETTP) Uranium Hexafluoride ($UF_6$) cylinder storage yards. Dose rate measurements are taken at the Perimeter fence lines using Landauer® Luxel® optically stimulated luminescence (Aluminum Oxide) dosimeters. Monitoring of ambient gamma levels at the $UF_6$ cylinder storage yards began in April 1999 and has continued to date. The data gathered are being used to determine if areas monitored have exceeded state and/or federal regulatory limits for exposure to members of the public. Data are also being used to determine if environmental concerns are warranted and what, if any, remediation actions are necessary before this property is free released and/or prior to occupation by companies during the planned reindustrialization of the ETTP site. In this study period from January 2003 to January 2004, dose rates in excess of the 100-mrem/yr. state/federal exposure limit were observed at all five of the monitored cylinder yards. Specific location data have been obtained for all stations with the use of GPS instrumentation. This specific location data, along with its corresponding radiological data, will be incorporated into the MapInfo computer program. With this, the user has the ability to locate an individual monitoring point and view its radiological history.

**Introduction**

During the development and operation of the gaseous diffusion uranium enrichment process; containers, support equipment, and support facilities were designed, constructed, and used to store, transport, and process the depleted $UF_6$. After a significant inventory was produced, outdoor storage facilities (i.e., cylinder yards) evolved. Today, the Bechtel Jacobs Company operates the six ETTP $UF_6$ cylinder storage yards for the DOE. They are used for the temporary and long-term storage of $UF_6$ cylinders. The goal of the division's $UF_6$ cylinder yard dose assessment program is to evaluate the level at which the public is protected from radiation doses emitted from the cylinder yards. This is especially important since DOE's mission is the continual transformation of ETTP into a commercial industrial park.

**Materials and Methods**

Dosimeters measure the dose from exposure to gamma radiation over time. The division's cylinder yard monitoring is performed using one type of dosimeter, Aluminum Oxide. They are obtained from Landauer®, Inc., Glenwood, Illinois. Aluminum Oxide dosimeters (minimum reporting value of 1 mrem) are generally placed in areas where exposures are expected to be significantly higher than background. The dosimeters are collected by division staff and shipped to Landauer® for processing. To account for exposures that may be received in transit or storage, control dosimeters are included in each shipment from the Landauer® Company. The control dosimeters are stored in a shielded container, at the division's office, and returned to Landauer® with the field-deployed dosimeters for processing. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division's office (761 Emory Valley Road, Oak Ridge, Tennessee), is subtracted from the exposure reported for the field-deployed dosimeters by Landauer. Annually, the quarterly exposures (minus the exposure obtained from the control dosimeter) are summed for each location. The resultant annual dose is compared to the state/DOE primary dose limit for members of the public (100 mrem/yr exposure).

**Discussion and Results**

The division's Ambient Gamma Radiation Monitoring program has determined that there is an elevated exposure potential to the public at all five of the monitored cylinder yards. At these yards, the total adjusted accumulated annual dose, as measured by dosimeter, has ranged from a low of 25 mrem at the K-1066-J to a high of 8257 mrem at the K-1066-L yard. Both of these values are down from last year. Within this range, there are numerous elevated data points that are shown in Tables 1-5. These results are compared with the state/DOE primary dose limit for members of the public (100 mrem/yr total exposure). The mapping and recording of dose rate data will ensure that workers/non-DOE workers under ETTP's reindustrialization plan and the public will be knowledgeable of and protected from the cylinder yard's radiation source.

The following ETTP cylinder yards under the dosimeter project are: K-1066-K, K-1066-E, K-1066-J, K-1066-B, K-1066-L.

Current and future plans by ETTP to prepare cylinders for yard-to-yard movement and off-site shipment will necessitate "shuffling" cylinders between various yards. Due to this activity, there have been some wide variances in the dosimeter readings from quarter-to-quarter. These have all been checked and correlated with redistribution activity of the cylinders. Plans are in place for 2004, to evaluate the current positions of TLDs and relocate those necessary to insure perimeter coverage of the yards due to recent redistribution of the cylinders. K-1066-F yard is not being monitored due to the fact it does not have an outside perimeter fence that could be accessed by the public.

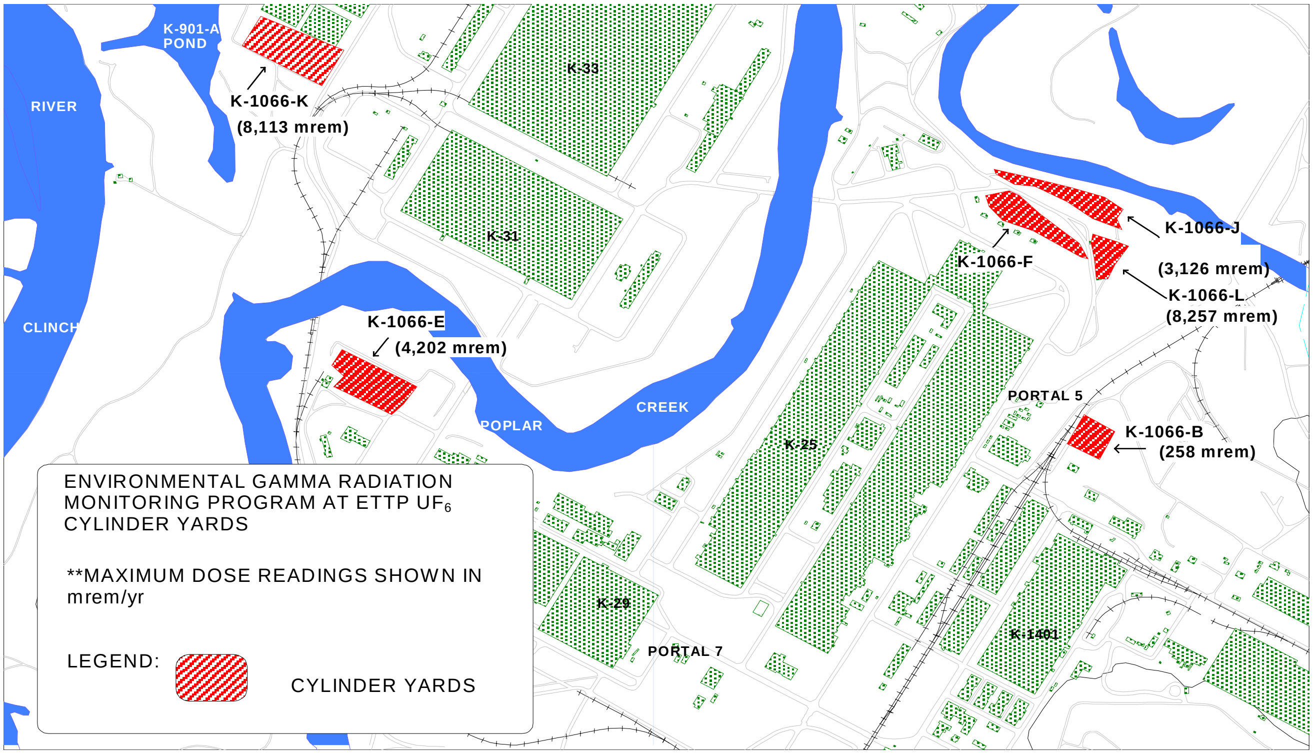

Figure 1: Map of ETTP showing location of cylinder yards.

**Table 1: Results from dosimeters deployed at ETTP $UF_6$ Cylinder Yards.**

K-1066-K
Yard

| Dosimeter Number | **Period 1** (01/23/03 - 04/23/03) (91 Day Exposure) Dosimeter Reading (mrem) | **Period 2** (04/24/03 - 07/23/03) (91 Day Exposure) Dosimeter Reading (mrem) | **Period 3** (07/24/03 - 10/30/03) (99 Day Exposure) Dosimeter Reading (mrem) | **Period 4** (10/31/03- 01/26/04) (88 Day Exposure) Dosimeter Reading (mrem) | Total Accumulated Dose Equivalent: 369days mrem | Total Adjusted Dose to 365 days mrem |
|---|---|---|---|---|---|---|
| 1 | 52 | 60 | 71 | 57 | 240 | 237 |
| 2 | 343 | 351 | 426 | 298 | 1418 | 1403 |
| 3 | 726 | 710 | 900 | 703 | 3039 | 3006 |
| 4 | 1107 | 1048 | 1321 | 1153 | 4629 | 4579 |
| 5 | 462 | 473 | 573 | 498 | 2006 | 1984 |
| 6 | 380 | 418 | 484 | 217 | 1499 | 1483 |
| 7 | 272 | 256 | 323 | 130 | 981 | 970 |
| 8 | 339 | 352 | 385 | 202 | 1278 | 1264 |
| 9 | 519 | 521 | 661 | 527 | 2228 | 2204 |
| 10 | 235 | 246 | 283 | 230 | 994 | 983 |
| 11 | 138 | 164 | 173 | 147 | 622 | 615 |
| 12 | 349 | 384 | 415 | 353 | 1501 | 1485 |
| 13 | 1307 | 1387 | 1602 | 1373 | 5669 | 5608 |
| 14 | 1898 | 2168 | 2255 | 1881 | 8202 | 8113 |
| 15 | 1352 | 1347 | 1570 | 1289 | 5558 | 5498 |
| 16 | 951 | 1017 | 1126 | 935 | 4029 | 3985 |
| 17 | 429 | 445 | 521 | 409 | 1804 | 1784 |
| 18 | 975 | 958 | 1140 | 932 | 4005 | 3962 |
| 19 | 1630 | 1764 | 1873 | 1506 | 6773 | 6700 |
| 20 | 1223 | 1377 | 1426 | 1147 | 5173 | 5117 |
| 21 | 131 | 161 | 168 | 140 | 600 | 593 |
| 22 | 329 | 348 | 344 | 315 | 1336 | 1322 |

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

* To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division's office, in a shielded container, and returned to the vender for processing along with the associated field-deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field-deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

**Table 2: Results from dosimeters deployed at ETTP $UF_6$ Cylinder Yards.**

K1066-E Yard

| Dosimeter Number | **Period 1** (01/28/03 - 04/24/03) (87 Day Exposure) Dosimeter Reading (mrem) | **Period 2** (04/25/03 - 07/22/03) (89 Day Exposure) Dosimeter Reading (mrem) | **Period 3** (07/23/03 - 10/31/03) (101 Day Exposure) Dosimeter Reading (mrem) | **Period 4** (11/01/03 - 01/27/04) (88 Day Exposure) Dosimeter Reading (mrem) | Total Accumulated Dose Equivalent: 365 days mrem | Total Adjusted Dose to 365 days mrem |
|---|---|---|---|---|---|---|
| 23 | 457 | 465 | 825 | 638 | 2385 | 2385 |
| 24 | 482 | 473 | 485 | 490 | 1930 | 1930 |
| 25 | 85 | 79 | 102 | 107 | 373 | 373 |
| 26 | 42 | 50 | 53 | 72 | 217 | 217 |
| 27 | 110 | 125 | 149 | 702 | 1086 | 1086 |
| 28 | 1001 | 913 | 948 | 1035 | 3897 | 3897 |
| 29 | 972 | 1016 | 1250 | 964 | 4202 | 4202 |
| 30 | 519 | 658 | 814 | 680 | 2671 | 2671 |
| 31 | 805 | 783 | 945 | 762 | 3295 | 3295 |
| 32 | 524 | 529 | 929 | 1021 | 3003 | 3003 |
| 33 | 587 | 977 | 1430 | 1061 | 4055 | 4055 |
| 34 | 348 | 356 | 430 | 314 | 1448 | 1448 |
| 35 | 119 | 159 | 190 | 170 | 638 | 638 |
| 36 | 257 | 280 | 356 | 314 | 1207 | 1207 |
| 37 | 220 | 223 | 294 | 279 | 1016 | 1016 |
| 38 | 184 | 152 | 188 | 221 | 745 | 745 |
| 39 | 146 | 145 | 162 | 191 | 644 | 644 |
| 76 | 44 | 33 | 36 | 46 | 159 | 159 |
| 77 | 49 | 39 | 36 | 60 | 184 | 184 |
| 78 | 32 | 38 | 42 | 49 | 161 | 161 |
| 79 | 88 | 97 | 110 | 165 | 460 | 715 |
| 80 | 293 | 310 | 364 | 325 | 1292 | 1292 |
| 81 | 334 | 334 | 427 | 345 | 1440 | 1440 |
| 82 | 265 | 298 | 370 | 310 | 1243 | 1243 |
| 83 | 247 | 257 | 299 | 250 | 1053 | 1053 |
| 84 | 126 | 149 | 172 | 159 | 606 | 606 |

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division's office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field-deployed dosimeters by Landauer.

**Table 3: Results from dosimeters deployed at ETTP $UF_6$ Cylinder Yards**

K1066-J
Yard

| Dosimeter Number | **Period 1** (01/29/03 - 04/24/03) (86 Day Exposure) Dosimeter Reading (mrem) | **Period 2** (04/25/03 - 07/22/03) (89 Day Exposure) Dosimeter Reading (mrem) | **Period 3** (07/23/03 - 10/31/03) (101 Day Exposure) Dosimeter Reading (mrem) | **Period 4** (11/01/03 - 01/27/04) (88 Day Exposure) Dosimeter Reading (mrem) | Total Accumulated Dose Equivalent: 364 days mrem | Total Adjusted Dose to 365 days mrem |
|---|---|---|---|---|---|---|
| 40 | 3 | 10 | 13 | 16 | 42 | 42 |
| 41 | 5 | 5 | 6 | 10 | 26 | 26 |
| 42 | 2 | 8 | 14 | 16 | 40 | 40 |
| 43 | 7 | 27 | 37 | 38 | 109 | 109 |
| 44 | 25 | 48 | 55 | 47 | 175 | 175 |
| 45 | 121 | 180 | 200 | 166 | 667 | 669 |
| 46 | 58 | 57 | 66 | 74 | 255 | 256 |
| 47 | 104 | 91 | 118 | 103 | 416 | 417 |
| 48 | 681 | 778 | 913 | 745 | 3117 | 3126 |
| 49 | 345 | 378 | 460 | 364 | 1547 | 1551 |
| 50 | 358 | 401 | 462 | 395 | 1616 | 1620 |
| 51 | 270 | 273 | 391 | 385 | 1319 | 1323 |
| 52 | 314 | 357 | 410 | 287 | 1368 | 1372 |
| 53 | 51 | 160 | 162 | 138 | 511 | 512 |
| 54 | 37 | 95 | 102 | 86 | 320 | 321 |
| 55 | 16 | 41 | 41 | 37 | 135 | 135 |
| 85 | M | 5 | 7 | 13 | 25 | 25 |
| 86 | 7 | 21 | 23 | 18 | 69 | 69 |
| 87 | 16 | 32 | 47 | 38 | 133 | 133 |
| 88 | 33 | 63 | 76 | 64 | 236 | 237 |
| 89 | 79 | 104 | 120 | 103 | 406 | 407 |
| 90 | 65 | 75 | 96 | 81 | 317 | 328 |
| 91 | 68 | 76 | 88 | 71 | 303 | 304 |
| 92 | 55 | 63 | 74 | 72 | 264 | 265 |

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division's office, in a shielded container, and returned to the vender for processing along with the associated field deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division office, is subtracted from the exposure reported above for the field-deployed dosimeters by Landauer.

M= Below minimum reportable quantity.

**Table 4: Results from dosimeters deployed at ETTP $UF_6$ Cylinder Yards.**

K1066-B
Yard

| | **Period 1** (01/29/03 - 04/23/03) (85 Day Exposure) | **Period 2** (04/24/03 - 07/22/03) (90 Day Exposure) | **Period 3** (07/23/03 - 10/31/03) (101 Day Exposure) | **Period 4** (10/22/02- 01/28/03) (87 Day Exposure) | Total Accumulated Dose Equivalent: 363 days | Total Adjusted Dose to 365 days |
|---|---|---|---|---|---|---|
| Dosimeter Number | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | mrem | mrem |
| 56 | 21 | 26 | 27 | 26 | 100 | 101 |
| 57 | 62 | 50 | 57 | 48 | 217 | 218 |
| 58 | 42 | 35 | 52 | 39 | 168 | 169 |
| 59 | 59 | 65 | 71 | 62 | 257 | 258 |
| 60 | 31 | 32 | 39 | 36 | 138 | 139 |
| 61 | 45 | 53 | 59 | 48 | 205 | 206 |
| 62 | 42 | 52 | 37 | 48 | 179 | 180 |
| 63 | 34 | 39 | 46 | 42 | 161 | 162 |
| 64 | 26 | 20 | 32 | 28 | 106 | 107 |
| 65 | 16 | 15 | 25 | 20 | 76 | 76 |
| 66 | 11 | 13 | 14 | 17 | 55 | 55 |
| 67 | 5 | 14 | 12 | 14 | 45 | 45 |
| 93 | 20 | 25 | 36 | 30 | 111 | 112 |
| 94 | 31 | 32 | 31 | 26 | 120 | 121 |
| 95 | 36 | 32 | 43 | 35 | 146 | 147 |
| 96 | 40 | 36 | 46 | 43 | 165 | 166 |
| 97 | 10 | 12 | 10 | 15 | 47 | 47 |
| 98 | 2 | 8 | 7 | 10 | 27 | 27 |
| 99 | 7 | 7 | 7 | 10 | 31 | 31 |
| 100 | 7 | 11 | 12 | 10 | 40 | 40 |
| 101 | 5 | 3 | 13 | 14 | 35 | 35 |
| 102 | M | 13 | 21 | 13 | 47 | 47 |
| 103 | 12 | 10 | 8 | 12 | 42 | 42 |

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division's office, in a sealed container, and returned to the vender for processing along with the associated field-deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division's office, is subtracted from the exposure reported above for the field-deployed dosimeters by Landauer.
M= Below minimum reportable quantity.

**Table 5: Results from dosimeters deployed at ETTP $UF_6$ Cylinder Yards.**

K1066-L Yard

| | **Period 1** (01/29/03 - 04/24/03) (86 Day Exposure) | **Period 2** (04/25/03 - 07/22/03) (89 Day Exposure) | **Period 3** (07/23/03 - 10/31/03) (101 Day Exposure) | **Period 4** (11/01/03- 01/28/04) (88 Day Exposure) | Total Accumulated Dose Equivalent: 368 days | Total Adjusted Dose to 365 days |
|---|---|---|---|---|---|---|
| Dosimeter Number | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | Dosimeter Reading (mrem) | mrem | mrem |
| 68 | 50 | 56 | 60 | 57 | 223 | 224 |
| 69 | 61 | 68 | 85 | 70 | 284 | 285 |
| 70 | 68 | 81 | 99 | 83 | 331 | 332 |
| 71 | 1497 | 1517 | 1801 | 1386 | 6201 | 6218 |
| 72 | 1932 | 1961 | 2246 | 1832 | 7971 | 7993 |
| 73 | 2035 | 2099 | 2107 | 1993 | 8234 | 8257 |
| 74 | 1085 | 1126 | 1288 | 1103 | 4602 | 4615 |
| 75 | 803 | 824 | 1030 | 868 | 3525 | 3535 |

*The primary dose limit for members of the public specified in both DOE Order 5400.5 (Radiation Protection of the Public and the Environment) and 10 CFR Part 20 (Standards for Protection against Radiation) is 100 mrem/yr total effective dose equivalent, exclusive of the dose contributions from background radiation, any medical administration the individual has received, or voluntary participation in medical research programs. The NRC limit for a decommissioned facility is 25 mrem/yr.

*To account for background radiation and any exposures that may be received in transit or storage, control dosimeters are provided by the vender. These dosimeters are stored at the division's office, in a shielded container, and returned to the vender for processing along with the associated field-deployed dosimeters. Any exposure received by the control dosimeters, which would include background radiation received while in storage at the division's office, is subtracted from the exposure reported above for the field-deployed dosimeters by Landauer.
M= Below minimum reportable quantity.

## Conclusions

The data are showing elevated readings at all five cylinder yards. These annual doses are in excess of the state/DOE primary dose limit for members of the public where the public has access. The yards may also produce ten or fifteen percent additional mrems in neutron as well as gamma doses. Neutron dosimetry is being gathered in another division program.

## References


Bechtel Jacobs Company, LLC. 1998. *East Tennessee Technology Park $UF_6$ Cylinder Yards Final Safety Analysis Report.*

Tennessee Department of Environment and Conservation. Department of Energy Oversight Division. 2001. *Environmental Monitoring Plan January through December 2001.*

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

U.S. Department of Energy. Office of Nuclear, Science and Technology. 1999. *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride.*

Yard, C.R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation. Department of Energy Oversight Division., Oak Ridge, Tennessee.

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Real Time Ambient Gamma Monitoring of the Oak Ridge Reservation

Principal Authors: Howard Crabtree, Gary Riner

**Abstract**

In 2003, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) maintained gamma exposure rate monitors at a background location (Fort Loudoun Dam), spent nuclear fuel wells at SWASA 5 North (ORNL), Y-12's Industrial Landfill, the 3513 Waste Holding Basin (ORNL), the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (Bear Creek Valley). Measurements collected from these sites ranged from 0 μR/hr to 1,764 μR/hr. The highest exposure rates were recorded at the boundary of a radiation area surrounding sediments dredged from the 3513 Waste Holding Basin. Dose rates at this location averaged 1,739 μR/hr, which is equivalent to 1.7 mrem/hr for gamma radiation. While not a DOE requirement, these values approach limits specified by state and Nuclear Regulatory Commission regulations requiring their licensees to conduct operations in such a manner that the external dose in any unrestricted area not exceed 2.0 mrem in any one hour.

**Introduction**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) has deployed continuously recording exposure rate monitors on the Oak Ridge Reservation (ORR) since 1996. While the environmental dosimeters used in the division's Ambient Monitoring Program provide the cumulative dose over the time period monitored, the results cannot account for the specific time, duration, and magnitude of fluctuations in the dose rates. Consequently, a series of small releases cannot be distinguished from a single large release, using the dosimeters alone. The continuous exposure rate monitors record gamma radiation levels at short intervals (e.g., 1 minute), providing an exposure rate profile that can be correlated with activities or changing conditions at the site. The instruments have primarily been used to record exposure rates during remedial activities and to supplement the integrated dose rates provided by the division's environmental dosimetry.

In 2003, the exposure rate monitors were placed at a background station and five sites associated with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities. These locations included: the 3513 Waste Holding Basin at the Oak Ridge National Laboratory (ORNL); Solid Waste Storage Area (SWSA) 5 North, the Environmental Restoration Coal Yard Storage Area (ORNL), and the Environmental Management Waste Management Facility (EMWMF) located in Bear Creek Valley at Y-12.

**Methods and Materials**

The exposure rate monitors used in the program are manufactured by Genitron Instruments and marketed under the trade name GammaTRACER.® Each unit contains two Geiger-Mueller tubes, a microprocessor controlled data logger, and lithium batteries sealed in a weather resistant case to protect the internal components. The instruments can be programmed to measure gamma exposure rates from 1 μR/hr to 1 R/hr at predetermined intervals (one minute to two hours). The results reported are the average of the measurements recorded by the two Geiger-Mueller detectors, but data from each detector can be accessed, if needed. Information recorded by the data loggers is downloaded to a computer using an infrared transceiver and associated software.

Monitoring in the program focuses on the measurement of exposure rates under conditions where gamma emissions can be expected to fluctuate substantially over relatively short periods and/or there is a potential for the unplanned release of gamma emitting radionuclides to the environment. The results are compared to background measurements collected at Fort Loudoun Dam in Loudoun County and appropriate standards. Candidate monitoring locations include: remedial activities, waste disposal operations, pre and post operational investigations, and emergency response activities.

**Results and Discussion**

The amount of radiation an individual can be exposed to is restricted by state and federal regulations. The primary dose limit for members of the public specified by these regulations is a total effective dose equivalent* of 100 mrem in a year. Since there are no agreed upon levels where exposures to radiation constitute no risk, radiological facilities are also required to maintain exposures as low as reasonably achievable (ALARA). Table 1 provides some of the more commonly encountered dose limits.

**Table 1: Commonly encountered Dose Limits for exposures to Radiation**

| Dose Limit | Application |
|---|---|
| 5,000 mrem/year | Maximum annual dose for radiation workers |
| 100 mrem/year | Maximum dose to a member of the general public |
| 25 mrem/year | Limit required by state regulations for free release of facilities that have been decommissioned |
| 2 mrem in any one hour period | The state limit for the maximum dose in an unrestricted area in any one hour period |

The unit used to express the limits (rem) refers to the dose of radiation an individual receives; that is, the radiation absorbed by the individual. For alpha and neutron radiation, the measured quantity of exposure, roentgen (R), is multiplied by a quality factor to derive the dose. For gamma radiation, the roentgen and the rem are generally considered equivalent. It should be understood, the monitors used in this program only account for the doses attributable to external exposures from gamma radiation. Any dose contribution from alpha, beta, or neutron radiation would be in addition to the measurements reported.

In 2003, gamma monitoring stations for the program included the background location at Fort Loudoun Dam, SWSA 5 North (near spent nuclear fuel wells), Y-12's Industrial Landfill, two sites associated with the Surface Impoundments Operable Unit (SIOU) Remedial Action at ORNL (the 3513 Waste Holding Basin and a storage area for sediments removed from the basin), and the weigh-in station for the Environmental Management Waste Management Facility.

*Fort Loudoun Dam Background Station:* Background exposure rates fluctuate over time due to various phenomena that alter the quantity of radionuclides in the environment and/or the intensity of radiation being emitted by these radionuclides. For example, the gamma exposure rate above soils saturated with water after a rain can be expected to be lower than that over dry soils, because the moisture shields radiation released by terrestrial radionuclides. To better assess exposure rates

* Dose equivalent is the product of the absorbed dose in tissue and a quality factor. Total Effective Dose Equivalent means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). The deep dose equivalent refers to the dose equivalent in tissue at 1 cm derived from external (penetrating) radiation. Dose contributions from background radiation and medical applications are not included in the dose calculation

measured on the reservation and the influence that natural conditions have on these rates, division personnel maintain one of the division's gamma monitors at Fort Loudoun Dam in Loudon County to collect background information. Figure 1 depicts the exposure rates measured at the background station from 12/30/02 to 12/31/03. Over this period exposure rates averaged 8.4 μR/hr and ranged from 7 to 13 μR/hr.

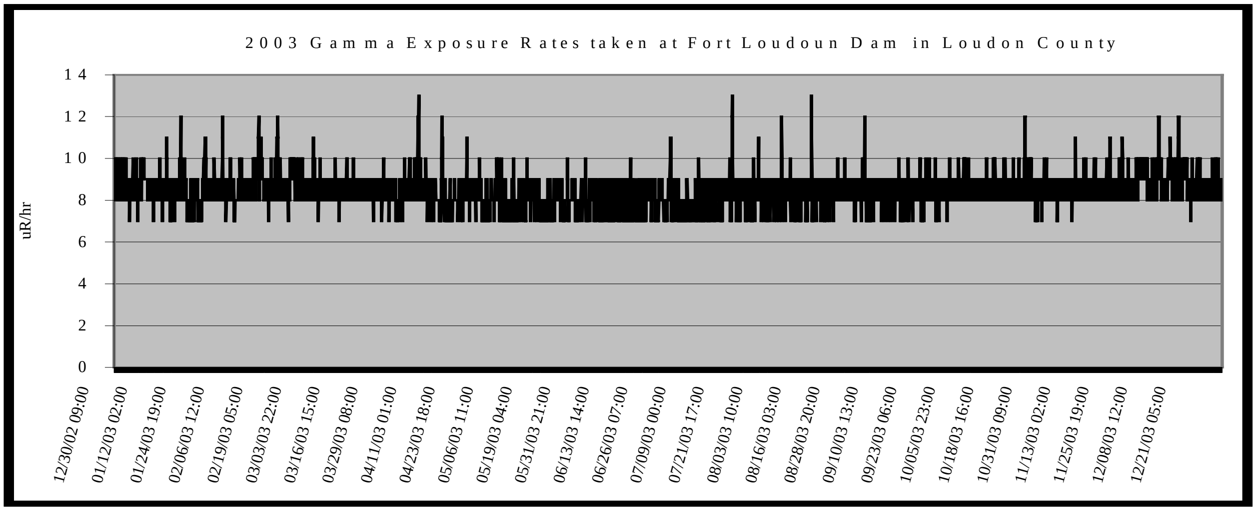
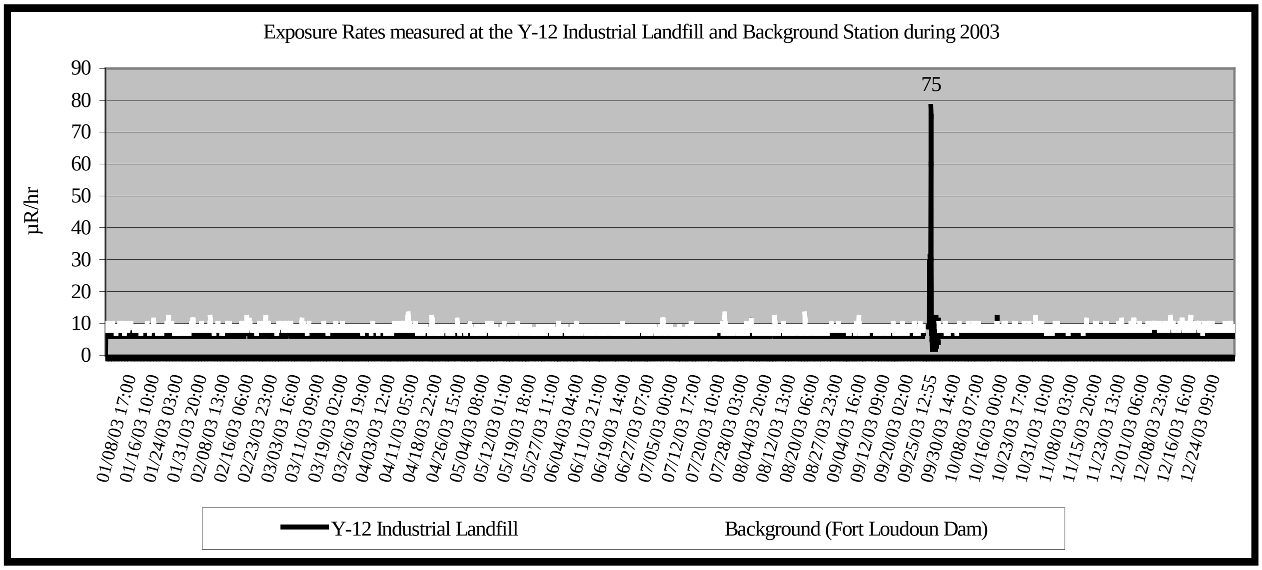



**Figure 1: 2003 Results of Exposure Rate Monitoring at the Background Station located at Fort Loudoun Dam in Loudon County**

On average, individuals in the United States receive a dose from natural sources of radiation of approximately 300 mrem per year. To put the dose limits in perspective, a person exposed to naturally occurring gamma radiation, alone, at the average level recorded at Fort Loudoun Dam would receive a dose equivalent to the primary dose limit (100 mrem/yr) in 496 days.

*The Y-12 Industrial Landfill:* The Y-12 Industrial Landfill is permitted by TDEC's Division of Solid Waste Management with the provision that the facility shall not dispose of radioactive Wastes; although, less stringent standards are being discussed. For the purposes of the agreement, wastes containing less than 35 pCi/g of uranium are not considered radioactive. While wastes are screened prior to disposal at the facility, instances have occurred where radionuclides have been found at the landfill in violation of this agreement.

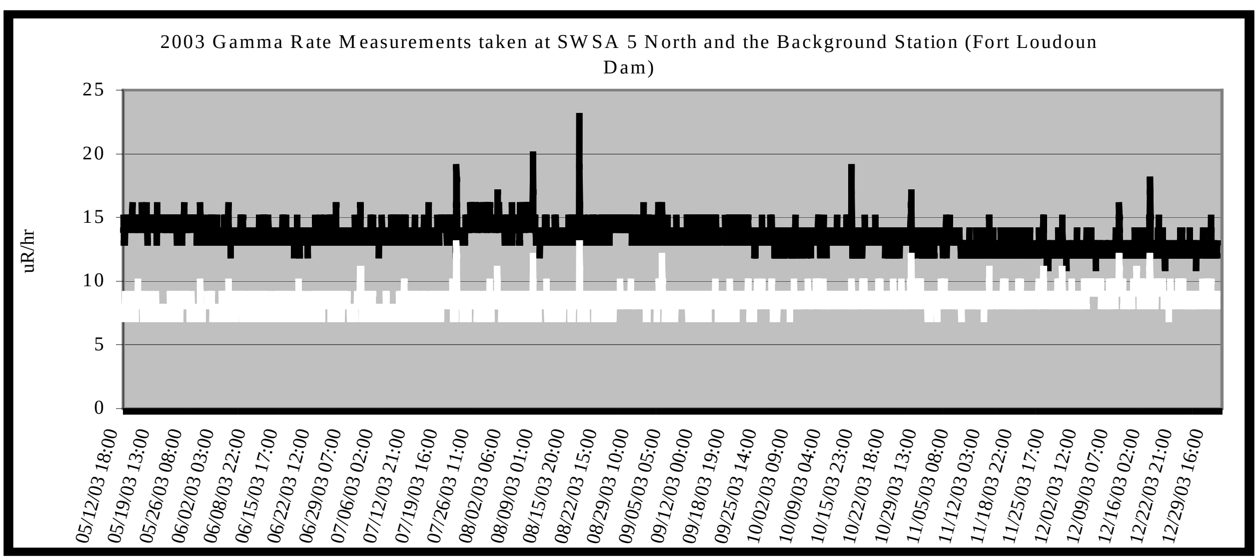
On December 11, 2002, staff placed one of the gamma monitors at the entrance to the facility to measure gamma activity as wastes were transported through the gate for disposal. The monitor was programmed to increase the frequency of measurements recorded from one hour to one-minute intervals, if exposure levels exceeded 20 µR/hr. For 2003, the measurements ranged from 2 to 78 µR/hr and averaged 6.8 µR/hr. As can be seen in Figure 2, the data recorded at the landfill were very similar to the results reported for the background station, with the exception of measurements taken from 12:47 PM to 01:03 PM on 09/25/03. The rise in gamma exposure rates suggested the presence of radionuclides not approved for disposal at the facility. An investigation by the division's Waste Management Program indicated no waste was delivered during the period of the elevated results, but a radiation source was being used during the period to calibrate radiation detection equipment maintained by the landfill and located adjacent to the gamma monitor. The calibration source appears likely to have been the cause of the elevated readings.




The state dose limit to an unrestricted area is 2 mrem (2,000 µR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

**Figure 2: 2003 Gamma Exposure Rates measured at the Entrance to the Y-12 Industrial Landfill and Background Measurements (Fort Loudoun Dam)**

*SWSA 5 North, Spent Nuclear Fuel (SNF) Wells:* In 1995, DOE Headquarters directed DOE sites with smaller inventories of spent nuclear fuel to prepare and ship the material to the Savannah River Site in South Carolina and/or the Idaho National Engineering and Environmental Laboratory (INEEL) in Idaho. Three shipments of Oak Ridge SNF were sent to the Savannah River site in 1998. An additional five shipments (the last of the Oak Ridge SNF) were shipped to INEEL in December 2003. To complete this process, the highly radioactive SNF had to be transferred from the storage facilities in SWSA 5 North, to shipping casks, then to the transport vehicles. On 5/12/03, one of the gamma monitors was stationed in the vicinity of the storage area to measure exposure rates during the process (Figure 3).



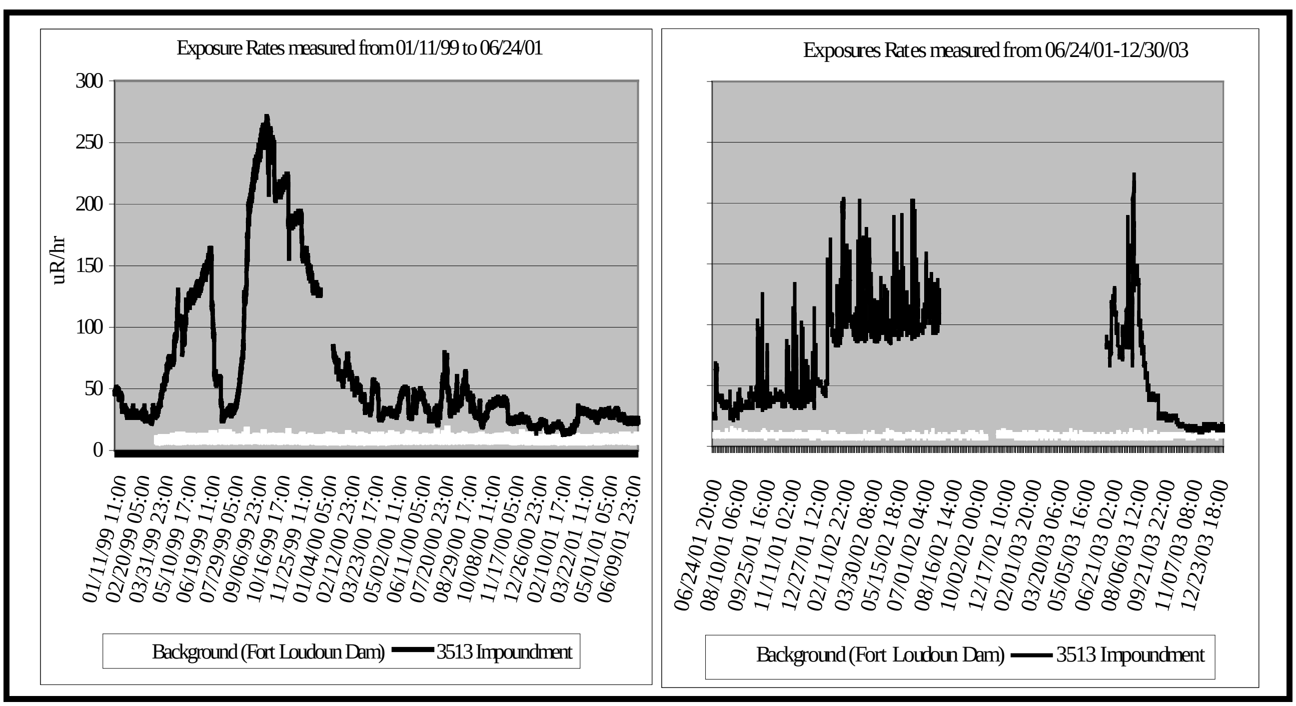

The state dose limit to an unrestricted area is 2 mrem (2,000 µR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

**Figure 3: 2003 Gamma Rate Measurements taken at SWSA 5 North and the Background Station (Fort Loudoun Dam)**

As can be seen in Figure 3, the ambient levels of gamma radiation at SWSA 5 North were nearly twice the background measurements. These results are believed to be due to radioactive materials buried, spilled, and/or released from the shallow burial trenches characteristic of the site. From 05/12/03 to 12/31/03, exposure rates measured at the sight ranged from 11 to 23 μR/hr and averaged 13.6 μR/hr. While peaks are visible in the data represented in Figure 3, no significant releases that can be attributed to the transfer and removal of the SNF were noted.

*3513 Waste Holding Basin, Surface Impoundment Operable Unit (SIOU) Remedial Action):* From 1944 to 1976, the 3513 Waste Holding Basin served as a settling pond for ORNL effluents, prior to their release to White Oak Creek. Consequently, sediments at the bottom of the basin accumulated significant amounts of radioactive materials. These wastes included an estimated 200 curies of cesium-137, 30 curies of strontium-90, and 5 curies of cobolt-60, europium-154, plutonium-238, plutonium-239, americium-241, and curium-244 (Bechtel, 1992): A CERCLA Record of Decision issued by DOE (September 24, 1997) provided for the removal and disposal of the contaminated sediments in the 3513 Impoundment and the adjacent 3524 Equalization Basin (which also received radioactive wastes, historically). As part of the SIOU Remedial Action, the sediments were removed from the basins, dewatered, mixed with concrete to form large monoliths, and disposed in the EMWMF.

In order to measure the effectiveness of this action, division staff attached an exposure rate monitor to a tree located approximately 28 feet from the 3513 Impoundment in 1999 (prior to remedial activities). From 01/11/99 to 012/30/03 the exposure rates measured at the basin averaged 69 μR/hr and ranged from 11 to 271 μR/hr. Figure 4 plots the exposure rates recorded at 3513 basin during this period, along with background data collected at Fort Loudoun Dam.



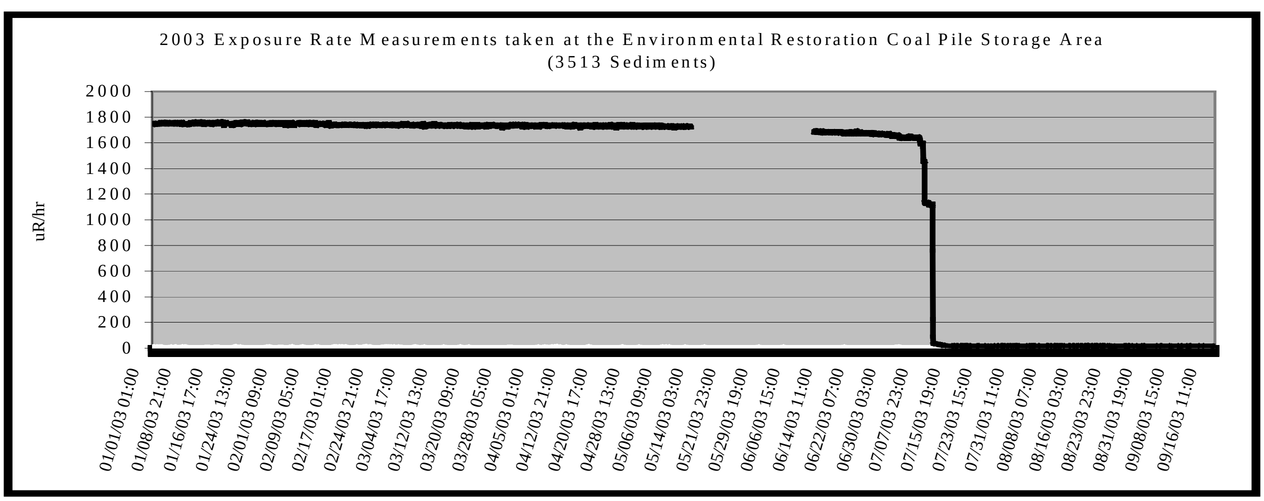

The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

**Figure 4: 2003 Results of Gamma Exposure Rate Monitoring at the 3513 Waste Holding Basin and Background Measurements taken at Fort Loudoun Dam**

To a large degree, significant fluctuations in the exposure rates at the 3513 Waste Holding Basin can be attributed to changes in the water level in the impoundment. The water in the basin shielded gamma radiation emitted by the contaminants contained in the sediments. Increased water levels during the wetter months enhanced this effect and provided shielding to previously exposed sediments at the basin perimeter, resulting in lower exposure rates. The peak that can be noted in Figure 4 during the summer of 1999 was due to the lowering of the water level to repair a seep that was observed in the berm that separates the basin from White Oak Creek. During 1999, the exposure rates averaged 116 μR/hr. In the summer of 2000, sediments from the 3524 Equalization Basin were transferred to the 3513 Impoundment in preparation for their final removal and disposal. During this effort, the water level in the basin was maintained to reduce radiation emitted by the sediments and the potential for contaminants to becoming airborne. As a consequence, the exposure rates at 3513 decreased. In 2000, the exposure rates at the basin averaged 39.1 μR/hr.

In 2001, DOE contractors began removing the sediments from the 3513 Basin (including those previously in 3524). The exposure rates in 2001 averaged 33 μR/hr. The sediment removal process continued through 2003, but the gamma monitor had to be removed in July 2002 for routine maintenance and calibration. From 01/03/02 to 07/04/02 measurements at 3513 were higher than the two previous years ranging from 88 to 107 μR/hr and averaging 105 μR/hr. The gamma monitor was returned to the site in June 2003, as the remediation was nearing completion. The remainder of the sludges was removed and the basin filled and capped. Measurements taken during this period ranged from 12 to 223 μR/hr and averaged 49 μR/hr. Since the completion of the project, the measurements have continued to decline, averaging approximately 16 μR/hr for the last quarter of 2003.

*3513 Waste Holding Basin Sediments stored at the Environmental Restoration Coal Yard Storage Area:* As sediments were removed from the 3513 Basin, they were dewatered then mixed with cement to form large concrete monoliths. No longer shielded by the water in the pond, the monoliths were packaged in Department of Transportation liners and stored in radiation control areas at various locations across the ORNL campus. To assess the hazard the sediments might present, a gamma monitor was placed near the radiation area boundary at one of these sites, the Environmental Restoration Coal Yard Storage Area.



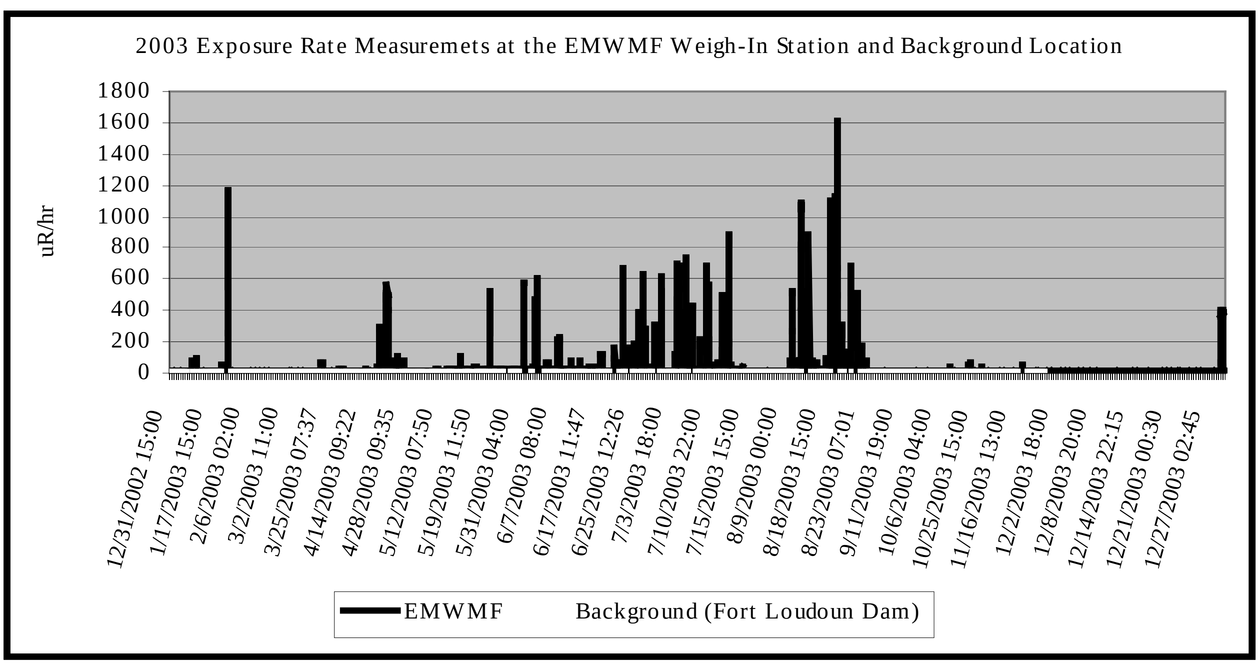

The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period.

**Figure 5: 2003 Results of Gamma Exposure Rate Monitoring at the Environmental Restoration Coal Yard Storage Area and Background Measurements**

Results for January 1 through May 12, 2003, (when monitoring was interrupted) ranged from 1,712 to 1,764 μR/hr (Figure 5) and averaged 1,739 μR/hr. These are some of the highest levels that have been measured in the program. While not a DOE regulation, the results approached the state and Nuclear Regulatory Commission (NRC) dose limit for unrestricted areas, 2 mrem (2,000 μR) in any one-hour period. As the sediment monoliths were removed from the storage area for disposal, the exposure rates abruptly declined. Measurements taken from 07/01/03 to 09/17/03 ranged from 15 to 23 μR/hr and averaged 17 μR/hr.

*The Environmental Management Waste Management Facility (EMWMF):* The EMWMF was constructed in Bear Creek Valley (near the Y-12 Plant) to dispose of wastes generated by CERCLA activities on the ORR. The EMWMF relies on a waste profile provided by the generator to characterize waste disposed in the facility. This profile is based on an average of contaminants in a waste lot. Since the size of waste lots can vary from a single package to many truckloads of waste, the averages reported are not necessarily representative of each load of waste transported to the facility. That is, some loads may have highly contaminated wastes, while other loads may contain very little contamination.

To get an idea of the variability in radioactive waste disposed at the EMWMF, one of the gamma monitors was secured at the facility's check-in station on 08/27/02. Each truck transporting waste for disposal is required to stop at this location, while the vehicle/waste is weighed and the driver processes the associated manifest. In 2003, the monitor was programmed to record measurements hourly at exposure rates below 40 μR/hr and at one-minute intervals at exposure levels above 40 μR/hr. For 2003, the measurements taken at the EMWMF ranged from 0 to 1,612 μR/hr (Figure 6) and averaged 18 μR/hr.




The state dose limit to an unrestricted area is 2 mrem (2,000 μR for gamma) in any one-hour period. The state dose limit for members of the public is 100 mrem in a year.

**Figure 6: 2003 Results of Gamma Exposure Rate Monitoring at the Weigh-In Station for the Environmental Management Waste Management Facility (EMWMF)**

When waste containing gamma emitters is not near the weigh station, the data reflected exposure levels similar to background measurements. As the trucks carrying gamma emitters pull into the weigh station, the exposure levels go up, peak as the waste moves past the monitor, then abruptly decline as the trucks pull away. While relatively high measurements can be observed, the duration of the elevated readings is only a few minutes. This coupled with the monitor's inability to read alpha and beta emissions results in relatively low average values, when compared to the maximum exposures measured.

As might be expected, the highest measurements that have been recorded at the EMWMF were for sediments taken from the 3513 and 3524 Basins at ORNL. Because of the radiological characteristics of the waste, it had initially been dispositioned for disposal at the Nevada Test Site (NTS). However, prior to shipment, a rule change at NTS resulted in the wastes being rejected because of the presences of PCBs. The sediments were subsequently accepted by the EMWMF for disposal, based on samples taken from the final waste form. That is, mixed with cement and formed into large concrete monoliths. While the addition of cement would tend to lower the concentrations of contaminants and provide some degree of shielding, the mass and radiological properties of the radionuclides present in the waste would be expected to remain the same. Measurements taken at the EMWMF weigh-in station when the sediments were delivered for disposal were up to three times higher than those of any other wastes previously monitored entering the facility.

**<u>Conclusion</u>**

The use of continuously recording gamma exposure monitors has proven to be a flexible and reliable method for monitoring gamma radiation on the reservation. The exposure rates recorded provide a profile that allows the time and magnitude of elevated gamma levels to be correlated with changing conditions. For example, gamma levels recorded hourly at the Y-12 Landfill for over a year were all similar to background measurements, except for one fifteen minute interval when the exposure rates rose an order of magnitude above the background levels. Elevated gamma levels suggest the presence of wastes containing radionuclides not approved for disposal at the facility. In this case, an investigation indicated no waste had been delivered during the period the anomalous results were recorded and that the probable cause of the elevated results was a radiation source being used at the time of readings to calibrate radiation detection equipment.

During monitoring at SWSA 5 North, no indication of a significant gamma release was noted during the loading of trucks preparing to transport spent nuclear fuel to INEEL. However, measurements taken at the site were consistently twice the background measurements taken at Fort Loudoun Dam. The elevated ambient gamma levels are believed to be due to past waste handling practices, spills, and leaks from the shallow burial trenches characteristic of the site.

During the four years the 3513 Waste Holding Basin has been monitored, the gamma exposure rates have been highly variable. To a large degree, changes in the exposure levels can be correlated with fluctuations in the water levels in the basin. When the water level was low, contaminated sediments at the basin perimeter were exposed, resulting in higher exposure rates. As the water levels rose, shielding was provided from the radiation emitted by the previously exposed sediments and the exposure rates decreased. In 1999, prior to remedial activities, the exposure rates ranged from 13 to 271μR/hr and averaged 116 μR/hr. After the sediments were removed and the impoundment filled, the exposure rates declined an order of magnitude and were consistently averaging approximately 16 μR/hr over the last quarter of 2003.

Sediments removed from the 3513 Waste Holding Basin exhibited very high exposure rates, once removed from the shielding provided by the water in the impoundment. Exposure rates measured at the boundary of a radiation area where the sediment were stored reached levels that were eighty-eight percent of state and NRC limits for the release of radiation to unrestricted areas and were the highest levels measured in the program to date. Measurements taken at the EMWMF weigh-in station when the sediments were delivered for disposal were up to three times higher than those of any other wastes previously monitored entering the facility.

**References**


Bechtel. 1992. *Site Characterization Summary Report for Waste Area Grouping 1 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR-1043/V1&D1. September 1992.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement. Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 2002. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2002.* December 2001. Oak Ridge, Tennessee.

U.S. Department of Energy (DOE). 2000. *The Surface Impoundment Operable Unit*. Fact Sheet. September 2000.

U.S. Science Applications International Corporation (SAIC), 2003. *2003 Remedial Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee.* DOE/OR/01-2058&D1. March 2003.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. May 2001. Oak Ridge, Tennessee.

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Biological Sampling and Radiochemical Analysis of Aquatic Plants (Macrophytes) at Spring Habitats on the Oak Ridge Reservation

Principal Author: Gerry Middleton


**Abstract**

This project is a continuation of a pilot vegetation (watercress) sampling and radiochemical analysis effort re-initiated by Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) staff in 2002 as part of environmental surveillance per the Tennessee Oversight Agreement. The current study was designed to correlate previous division and DOE groundwater radiochemistry and metals data with watercress/green algae (vegetation) radiochemistry and metals data from samples collected at the same ORR springs. Note that metals parameters were added to the sample data collected for 2003. The purpose was to determine biotoxicity of aquatic vegetation (bioaccumulation or uptake) in environmentally stressed spring (karst) habitats. Division staff gathered collateral vegetation monitoring data in support of the groundwater sampling of springs and surface water impacted by hazardous substances due to DOE operations. Sometimes, spring-fed creeks and ponds were sampled, if adequate amounts of aquatic vegetation were present. "Vegetation" sampled included watercress (*Nasturtium officinale*), other aquatic macrophytes (i.e., *Salvinia sp.*, *Sagittaria latifolia*, *Typha latifolia*, etc), and green algae. Thirty-eight (38) vegetation samples from both reference (offsite) and ORR springs/creeks/ponds were sampled during 2003. Collection times of samples were random and not dependent on the wet and dry season sampling events.


**Introduction**

Aquatic macrophytes (i.e., watercress, water spangles, arrowhead, and cattails) and green algae are environmental bioindicators and important pathways by which contaminants infiltrate the ORR ecosystem and food chain creating ecological and human health risks. Watercress; a floating, rooted, aquatic plant (macrophyte or angiosperm) was selected for its affinity to thrive around its natural habitat, in clear, lotic water near the mouth of springs and spring-fed creeks. Emerging spring water, if contaminated by hazardous substances, will impact the sediments. In turn, plants will uptake the contaminants both from the water and the sediments. Watercress is naturally high in calcium, alkaline salts, sulfur, and potassium, so it is likely that strontium (beta emitter) would be bioaccumulated as well, since calcium and strontium belong to the same group (Group IIA) of the periodic chart of the elements. Also, potassium and cesium belong to Group IA creating a similar scenario. During 2003, watercress was the main bioindicator sampled, supplemented with a few green algae, periphyton and aquatic macrophyte samples. Sampling of algae or other aquatic macrophytes was initiated and substituted when watercress was absent or too sparse for collection at spring sampling habitats. Care was taken during sample collections so as not to destroy floral populations.

Green algae and periphyton (benthic algae – diatoms) occur in most all the aqueous and many terrestrial habitats on the ORR (algae is ubiquitous). Algae forms colonies or filamentous mats ("blooms" or slick gelatinous mucilage) often covering a large area of a pond, waterfall ledges, lentic (still) or lotic (moving) water, or lake. They can be attached to various substrates such as submerged logs and snags, aquatic plants, sand, gravel, rocks, etc. Periphyton biomass is a primary producer generating much of the low-end of the food chain for many aquatic macroinvertebrates, fish, and herbivores. Periphyton are sensitive indicators of environmental physiochemical change in lotic waters and being benthic, the assemblage or population serves as a good bioindicator because of tolerance or sensitivity to specific changes in environmental conditions known for many algal species including diatoms (modified from U.S. DOE, April 2001).

Prospective habitats both offsite and onsite ORR such as springs, seeps, wetlands, ponds, spring-fed creeks, etc., received priority for sampling. Onsite ORR locations were selected based on their potential for being impacted by hazardous substances. An effort was made to collect samples from springs omitted during the first sampling season (2002). Table I provides field and sample data for each sampling station. Table II is a listing of springs (or creek/pond sites) sampled during 2003. Table III is a listing of available 2002 TDEC and DOE metals and radiological groundwater data to "cross-reference" the vegetation data collected during 2003. Existing historical spring (groundwater) analytical data collected by both the division and DOE subcontractors were used to target sampling sites as well. Figures 1 and 2 show all locations of the sampling sites.

**Methods and Materials**

Procedures employed during the project are consistent with those contained in the division's Work Plan for the Walkover Survey Program for field radiological surveys and aquatic sampling. Radiological instruments were used to scan bagged samples for beta and gamma radiation prior to delivery to the state Environmental Laboratory in Knoxville. Subsequently, the Knoxville laboratory forwards all radiological samples to Nashville (state of Tennessee Environmental Laboratories) for radiochemical analysis.

Arrangements were made with the appropriate TOA coordinators to expedite sampling in radiological control areas by having RADCON technicians available for sample and equipment screening. All samples collected in the field were double bagged in plastic zip-lock bags, marked and tagged, and packed in coolers with ice for transport to the lab. Field notes and chain-of-custody forms were recorded and documented at each field sampling station. Field samples were assigned consecutive identification numbers. QA/QC measures and field sampling equipment decontamination procedures were practiced to prevent cross-contamination and mix-up of field samples. Field coordinates (latitude/longitude) were recorded at each sampling station using a Garmin GPS II Plus field unit. Field sampling protocols and methods followed currently accepted and suggested guidelines of the Federal Radiological Monitoring and Assessment Center (FRMAC, 1998), the USGS (Porter, et al., 1993), the ASTM (Patrick, 1973), the division's "Health, Safety, and Security Plan", and the EPA (Barbour, et al., 1999).

Target radionuclides being mobile and occurring in the ORR environment as contamination include but are not limited to:

(1) Cesium-137
(2) Strontium-90
(3) Cobalt-60
(4) Technetium-99
(5) Uranium Isotopes and Daughter Products

Samples were analyzed for gross alpha, gross beta, and gross gamma parameters. Samples are ashed in a muffle furnace and analyses are performed on the ashed sample material. The gamma analysis follows the standard EPA (gamma) 901.1 method. The gross alpha and gross beta analysis is determined by counting 2 grams of ashed sample for two separate counts of 100 minutes.

The remaining ashed sample was then transferred to the metals laboratory for assays of the following parameters (EPA method 6010B): Antimony, Arsenic, Beryllium, Cadmium, Chromium, Total Cobalt, Copper, Iron, Lead, Magnesium, Nickel and Zinc.

**Results and Discussion**

The objectives of these oversight activities and studies include the detection and characterization of radionuclides and metals being bioaccumulated by both aquatic macrophytes and algal species in environmentally stressed ORR spring habitats and aquatic ecosystems ultimately affecting the lower food web. The division gathered thirty-eight (38) aquatic vegetation samples during 2003. The state wanted to determine if contaminated groundwater emerging from springs was also impacting aquatic plant species in the same sampling reach of the spring-fed creeks and streams. Historical spring groundwater sampling data from 2002 was assimilated from both division and DOE monitoring data. Division vegetation samples were compared to this historical spring groundwater analytical data to determine if a correlation in fact exists.

All gross alpha results were below 1.0 pCi/g. Eleven (11) vegetation samples collected during 2003 were above 5.0 pCi/g gross beta and the highest detected value was 12.871 pCi/g in a sample of Bur Weed/*Sparganium sp*. (BIOIND-03 - West Bear Creek Valley Seep). The next highest result for gross beta is from the Sycamore Spring (BIOIND-22) with a reported value of 9.39 pCi/g. There was one detection of cesium-137 (0.416 pCi/g reported result) from a green algae sample collected at Jones Island Creek (BIOIND-23). Although we are still gathering baseline data, the assumption is made for purposes of this current study that if concentrations of gross alpha, beta or gamma radionuclides are detected above 2.0 pCi/g (except for naturally-occurring radiological elements and irrespective of MDA's), then this scenario would be considered "above background." However, it is important to note that if any concentrations, even trace amounts, of fission products (i.e., Cs-137) are detected, then that certainly is considered above background. Unfortunately, there are only six (6) sites sampled in 2003 for which corresponding 2002 groundwater data was available for comparison purposes. These include: (1) Burns Cemetery Spring, (2) 21002 Spring, (3) USGS 10-895 Spring, (4) Bootlegger Spring, (5) SS 5.95km Spring, and (6) Aquarius Spring. In several of these cases, the data shows a clear correlation between groundwater and vegetation impacted by gross beta contamination sampled from the same monitoring sites. This assertion is best confirmed in radiological data collected from BIOIND-05 (21002 Spring - K25) and BIOIND-19 (SS-5.95km Spring – Y-12) in green algae and watercress, respectively shown in Table 1 when compared to corresponding groundwater data in Table 3.

Comparisons between groundwater and vegetation metals data for the six sites listed above were not feasible because detections of metals in the corresponding groundwater samples were almost nil except for trace amounts of zinc (e.g., 0.015 ppm). However, the vegetation samples showed some surprisingly high reported values for metals such as arsenic, cadmium, chromium, cobalt, copper, iron, lead, nickel, and zinc. In fact, the Mitchell Branch suite of vegetation metals samples (as reported) had the highest reported values of all 38 sites. Watercress collected at Mitchell Branch sites MIK-0.45 (BIOIND-28) and MIK-0.71 (BIOIND-29) had the following metals concentrations, respectively: arsenic-38 & 10 mg/kg, chromium-224 & 34.7 mg/kg, cobalt-39 &

28.7 mg/kg, copper-323 & 220 mg/kg, iron-43,300 & 28,800 mg/kg, lead-368 & 57.9 mg/kg, nickel-825 & 255 mg/kg, and zinc-1,460 & 1,760 mg/kg. Not surprisingly, metals results for watercress samples collected in McCoy Branch (Sadachbia Spring – BIOIND-11 and Upper McCoy Branch – BIOIND-12) also had elevated concentrations for copper and zinc. For unknown reasons, the Bootlegger North Spring (BIOIND-36) reference site at the UT Arboretum, the Norris Clear Creek reference site (BIOIND-20), and the George Jones Spring (BIOIND-34) at McKinney Ridge each had elevated concentrations of metals reported (especially cobalt, copper, lead, zinc, and nickel). It should be noted, and again for unknown reasons, that the green algae sample collected at the Norris Clear Creek reference site had a gross beta result of 5.56 pCi/g; the watercress sample for the same site had a result of 1.583 pCi/g. Finally, reported metals results for Bacon Spring watercress (BIOIND-04) had elevated concentrations of copper and zinc. Table 1 lists all the metals data for reference (Note: The "MDL" values associated with the metals data are actually laboratory MDLs).

Recent research in the phytoremediation field has shown that certain plant species "hyperaccumulate" (or bioaccumulate) metals and radiological constituents in soils and groundwater. The high metals concentrations in certain of our 2003 watercress and green algae samples suggest that certainly zinc, nickel, lead, iron, copper, cobalt, chromium, cadmium, and arsenic have been bioaccumulated and concentrated in the ORR vegetation to several magnitudes of order beyond which the groundwater data would indicate.

**Conclusions**

Adequate evidence of vegetation bioaccumulation of radionuclides and metals has been determined to warrant further investigations. Specifically, gross beta, zinc, arsenic, iron, chromium, lead, cobalt, copper, and nickel had elevated concentrations in several vegetation samples collected during 2003. Several aquatic vegetation samples showed gross beta activities above Sr-90 activities being considered as draft policy guidance by the Food and Drug Administration. The analytical concentrations per the Table I/Table 3 radiological data suggest a correlation between groundwater and aquatic vegetation samples collected from the same spring monitoring location(s). Comparison of metals data is inconclusive due to lack of data from corresponding groundwater sampling sites. The division will continue to sample aquatic vegetation both offsite and on the ORR to monitor aquatic ecosystem health and stream recovery. Future monitoring will involve an increase in periphyton and green algae sampling. Also, an effort will be made to select springs or surface water locations for vegetation (habitat sampling) targets where groundwater samples are actively being collected and analyzed for metals and radiological parameters by DOE.

**References**

AJA Technical Services. 2001. *Calendar Year 2000 Groundwater Monitoring Report for the Groundwater Protection Program, U.S. DOE, Y-12 National Security Complex, Oak Ridge, Tennessee."* Environmental Compliance Department, Environment, Safety & Health Organization, BWXT Y-12, L.L.C. (Y/SUB/01-006512/1).

Barbour, M.T., et al. 1999. *Rapid Bioassessment for use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.* Second Edition. EPA 841-B-99-002. Environmental Protection Agency. Washington, D.C.

Barnthouse, Lawrence W. December 1995. *Effects of Ionizing Radiation on Terrestrial Plants and Animals: A Workshop Report*. Environmental Sciences Division Pub. Np. 4494. ORNL/TM-13141. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Britton, L. J., and P.E. Greeson. 1989. *Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples*. Book 5, Chapter A4, Techniques of Water of Water Resources Investigations of the U. S. Geological Survey. U.S. Department of the Interior. U.S. Government Printing Office, Washington, D.C. http://www.deq.state.mt.us/ppa/mdm/SOP/pdf/12-1-2-0.pdf

Elvado Environmental LLC. March 2003. *Calendar Year 2002 – Groundwater Monitoring Report, U. S. Department of Energy, Y-12 National Security Complex, Oak Ridge, Tennessee.* Prepared for: Environmental Compliance Department. Environment, Safety, & Health Organization. Y-12 National Security Complex. Oak Ridge, Tennessee. BWXT Y-12, LLC. (Y/SUB/03-021559/1).

FRMAC. 1998. *FRMAC Monitoring and Sampling Manual, Vols. 1 & 2*. DOE/NV/11718-181-Vol. 1 & Vol. 2. Federal Radiological Monitoring and Assessment Center, Nevada Test Site. http://www.nv.doe.gov/programs/frmac/DOCUMENTS.htm

Patrick, R. 1973. *Use of Algae, Especially Diatoms, in the Assessment of Water Quality*. From Biological Methods for the Assessment of Water Quality (Edited by Cairns, J. and K.I. Dichson), pp. 76-95. American Society of Testing and Materials (ASTM), Philadelphia, Pennsylvania. http://www.astm.org

Porter, Stephen D., et al. 1993. *Methods for Collecting Algal Samples as Part of the National Water-Quality Assessment Program (NAWQA).* U.S. Department of the Interior. U.S. Geological Survey Open File Report 93-409. Raleigh, North Carolina.

Quinn, Tom. 2001. Integrating Aquatic Ecosystem Data. U.S. Department of the Interior. U.S. Geological Survey. Wyoming Department of Environmental Quality. Cheyenne, Wyoming. http://wy.water.usgs.gov/projects/emap/

Tennessee Department of Environment & Conservation. 2002. *Environmental Monitoring Report. January through December 2001*. Department of Energy Oversight Division. Oak Ridge, Tennessee.

Tennessee Department of Environment & Conservation. 2003. *Environmental Monitoring Report. January through December 2002.* Department of Energy Oversight Division. Oak Ridge, Tennessee.

U.S. Department of Energy. April 2001. *Biological Monitoring and Abatement Program (BMAP).* Oak Ridge National Laboratory, Environmental Sciences Division. http://www.esd.ornl.gov/BMAP

U.S. Environmental Protection Agency. August 2002. Biological Indicators of Watershed Health – *Periphyton as Indicators*. http://www.epa.gov/region09/lab/sop/1131.pdf

U.S. Food and Drug Administration. 2004. sec. 560.750. *Guidance Levels for Radionuclides in Domestic and Imported Foods*. (CPG 7119.14). Draft and Proposed Policy Guidance.

Yard, C.R. 2002. *Health, Safety and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

# Appendix

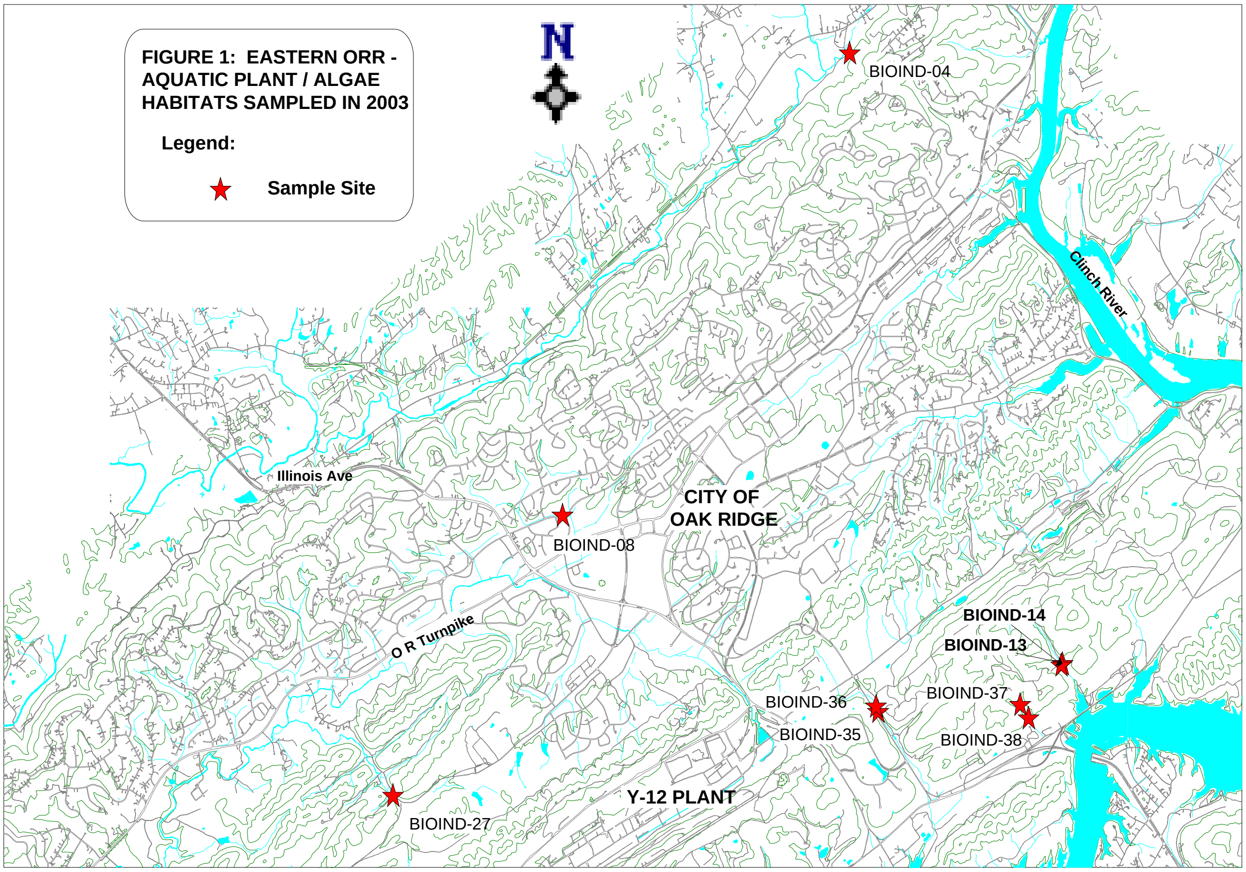

FIGURE 1: EASTERN ORR - AQUATIC PLANT / ALGAE HABITATS SAMPLED IN 2003
Legend:
Sample Site
N
BIOIND-04
Clinch River
Illinois Ave
CITY OF OAK RIDGE
BIOIND-08
O R Turnpike
BIOIND-14
BIOIND-13
BIOIND-36
BIOIND-37
BIOIND-35
BIOIND-38
Y-12 PLANT
BIOIND-27

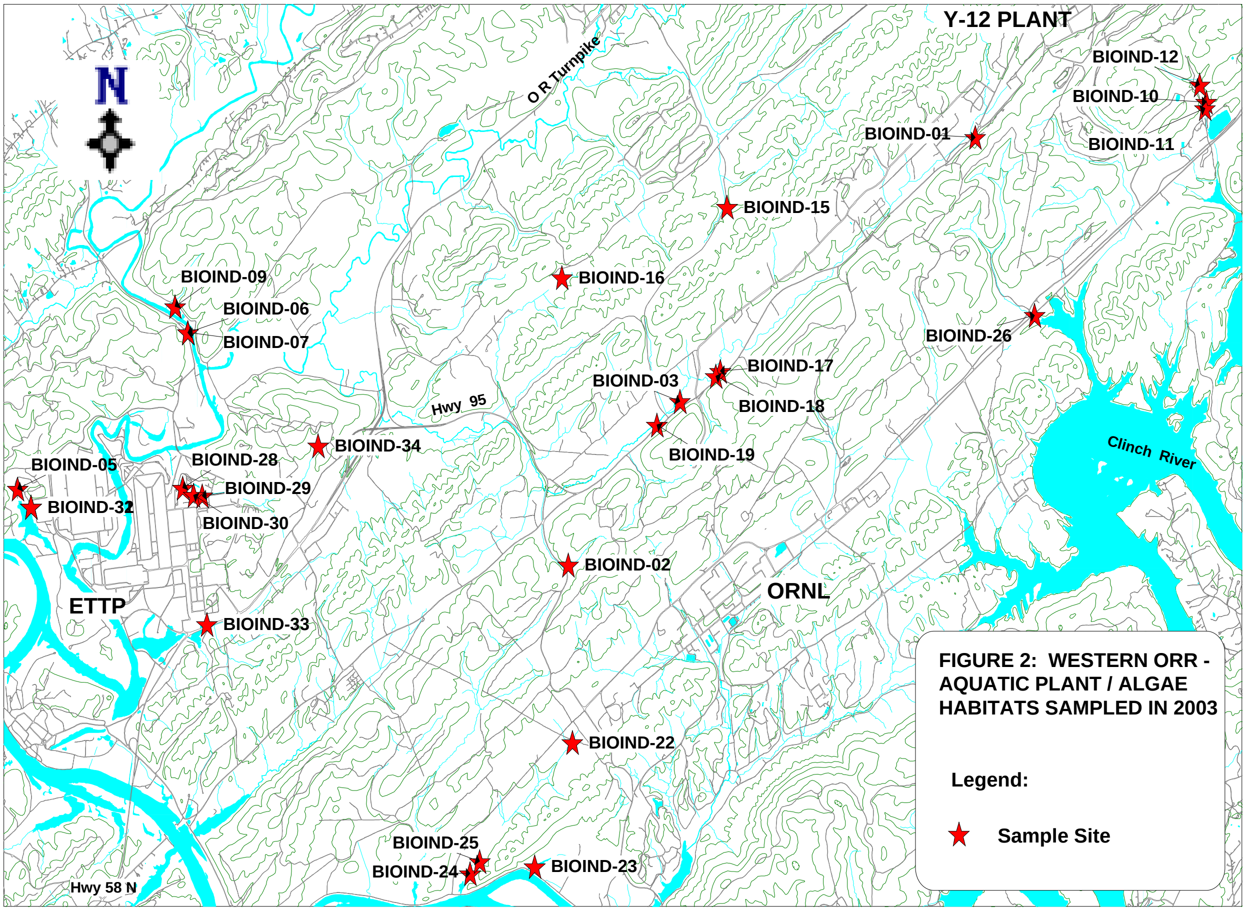
Y-12 PLANT
N
O R Turnpike
BIOIND-12
BIOIND-10
BIOIND-01
BIOIND-11
BIOIND-15
BIOIND-16
BIOIND-09
BIOIND-06
BIOIND-07
BIOIND-26
BIOIND-17
BIOIND-03
BIOIND-18
Hwy 95
BIOIND-34
BIOIND-19
BIOIND-05
BIOIND-28
BIOIND-29
BIOIND-32
BIOIND-30
Clinch River
BIOIND-02
ORNL
ETTP
BIOIND-33
FIGURE 2: WESTERN ORR - AQUATIC PLANT / ALGAE HABITATS SAMPLED IN 2003
BIOIND-22
Legend:
Sample Site
BIOIND-25
BIOIND-24
BIOIND-23
Hwy 58 N

TABLE 1, Pg.1

| SAMPLE SITE I.D. NO. >>> | BIOIND-1 | | BIOIND-2 | | BIOIND-3 | | BIOIND-4 | | BIOIND-5 | | BIOIND-6 | | BIOIND-7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | |
| **METALS** | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| (Units = mg/kg) | | | | | | | | | | | | | | |
| Antimony | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 |
| Arsenic | 29 | 2 | 8 | 2 | 22 | 2 | u | 2 | 9 | 2 | 9 | 2 | 9 | 2 |
| Beryllium | 3.3 | 0.1 | 0.8 | 0.1 | 0.7 | 0.1 | 1 | 0.1 | 0.7 | 0.1 | 0.3 | 0.1 | 0.3 | 0.1 |
| Cadmium | 4.5 | 0.1 | u | 0.1 | 1.7 | 0.1 | 4.9 | 0.1 | 0.4 | 0.1 | u | 0.1 | u | 0.1 |
| Calcium | 74,900 | 1,000 | 17,400 | 200 | 32,400 | 200 | 224,000 | 2,000 | 131,000 | 2,000 | 3,070 | 200 | 9,320 | 200 |
| Chromium, Total | 19 | 0.1 | 16.8 | 0.1 | 29.9 | 0.1 | 14.7 | 1 | 613 | 0.1 | 22.6 | 0.1 | 22.3 | 0.1 |
| Cobalt | 55 | 0.2 | 17.5 | 0.2 | 22.6 | 0.2 | 10.6 | 0.2 | 9.2 | 0.2 | 11.4 | 0.2 | 13.4 | 0.2 |
| Copper | 57.2 | 0.1 | 17.7 | 0.1 | 32.1 | 0.1 | 38.5 | 0.1 | 25.4 | 0.1 | 12.6 | 0.1 | 18.5 | 0.1 |
| Iron | 20,900 | 2.5 | 12,900 | 2.5 | 63,900 | 12.5 | 4,950 | 2.5 | 23,700 | 2.5 | 17,200 | 2.5 | 16,700 | 2.5 |
| Lead | 102 | 0.3 | 26.5 | 0.3 | 27.1 | 0.3 | u | 0.3 | 8.6 | 0.3 | 20.3 | 0.3 | 19 | 0.3 |
| Magnesium | 8,590 | 2 | 3,860 | 2 | 7,420 | 2 | 14,000 | 2 | 6,840 | 2 | 2,030 | 2 | 2,480 | 2 |
| Mercury | u | 0.1 | u | 0.1 | u | 0.1 | z | z | u | 0.1 | u | 0.1 | u | 0.1 |
| Nickel | 90 | 1 | 25 | 1 | 21 | 1 | 21 | 1 | 22 | 1 | 23 | 1 | 21 | 1 |
| Zinc | 488 | 0.1 | 131 | 0.1 | 206 | 0.1 | 686 | 0.1 | 486 | 0.1 | 88.4 | 0.1 | 85.6 | 0.1 |
| Percent Solids ( % ) | 12.9 | n/a | 18.8 | n/a | 11.3 | n/a | 8.7 | n/a | 20.4 | n/a | 26.1 | n/a | 14.5 | n/a |
| | | | | | | | | | | | | | | |
| **RADIO-CHEMIS.** | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR |
| (Units = pCi/g wet wt.) | | | | | | | | | | | | | | |
| Gross Alpha | 0.399 | 0.072 | 0.276 | 0.064 | 0.147 | 0.038 | 0.045 | 0.011 | 0.33 | 0.12 | 0.54 | 0.22 | 0.24 | 0.095 |
| Gross Beta | 3.58 | 0.15 | 1.432 | 0.094 | 12.871 | 0.029 | 1.79 | 0.045 | 6.47 | 0.33 | 6.13 | 0.42 | 2.7 | 0.19 |
| Gamma Nuclides | | | | | | | | | | | | | | |
| Ac-228 | 0.229 | 0.04 | y | y | y | y | y | y | y | y | y | y | 0.248 | 0.048 |
| Be-7 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-212 | y | y | y | y | 0.137 | 0.04 | y | y | y | y | y | y | y | y |
| Bi-214 | 0.213 | 0.027 | 0.184 | 0.028 | 0.092 | 0.015 | 0.051 | 0.012 | 0.556 | 0.043 | 0.356 | 0.055 | 0.146 | 0.026 |
| Cs-137 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| K-40 | 1.77 | 0.19 | 0.56 | 0.14 | 1.93 | 0.16 | 1.6 | 0.14 | y | y | 3.12 | 0.38 | y | y |
| Pb-212 | 0.097 | 0.014 | 0.092 | 0.015 | 0.0365 | 0.0076 | y | y | 0.127 | 0.018 | 0.35 | 0.035 | 0.11 | 0.019 |
| Pb-214 | 0.199 | 0.023 | 0.191 | 0.027 | 0.087 | 0.012 | 0.064 | 0.012 | 0.333 | 0.033 | 0.311 | 0.048 | 0.213 | 0.027 |
| Tl-208 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| | | | | | | | | | | | | | | |

TABLE 1, Pg. 2

| **SAMPLE SITE I.D. NO. >>>** | BIOIND-8 | | BIOIND-9 | | BIOIND-10 | | BIOIND-11 | | BIOIND-12 | | BIOIND-13 | | BIOIND-14 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **METALS** (Units = mg/kg) | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| Antimony | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 | u | 2 |
| Arsenic | 7 | 2 | 8 | 2 | 18 | 2 | 70 | 2 | 47 | 2 | 4 | 2 | 12 | 2 |
| Beryllium | 1.5 | 0.1 | 2.1 | 0.1 | 1.4 | 0.1 | 1.1 | 0.1 | 0.7 | 0.1 | 1.6 | 0.1 | 3.2 | 0.1 |
| Cadmium | 0.8 | 0.1 | u | 0.1 | 0.3 | 0.1 | 3.4 | 0.1 | 3.1 | 0.1 | 1.7 | 0.1 | 2.6 | 0.1 |
| Calcium | 14,400 | 200 | 3,750 | 200 | 79,600 | 1,000 | 81,200 | 1,000 | 37,300 | 200 | 114,000 | 2,000 | 39,500 | 200 |
| Chromium, Total | 26.3 | 0.1 | 16.4 | 0.1 | 25 | 0.1 | 24.2 | 0.1 | 13.5 | 0.1 | 16.7 | 0.1 | 38.1 | 0.1 |
| Cobalt | 17.1 | 0.2 | 9.7 | 0.2 | 16.3 | 0.2 | 21.1 | 0.2 | 11 | 0.2 | 14.3 | 0.2 | 16.6 | 0.2 |
| Copper | 24.3 | 0.1 | 7.1 | 0.1 | 20.9 | 0.1 | 46.9 | 0.1 | 30.5 | 0.1 | 26.6 | 0.1 | 17.3 | 0.1 |
| Iron | 21,200 | 2.5 | 13,100 | 2.5 | 24,500 | 2.5 | 18,400 | 2.5 | 14,400 | 2.5 | 17,500 | 2.5 | 15,900 | 2.5 |
| Lead | 129 | 0.3 | 22.2 | 0.3 | 8.3 | 0.3 | 6.9 | 0.3 | 8.5 | 0.3 | 5.9 | 0.3 | 20.6 | 0.3 |
| Magnesium | 5,180 | 2 | 1,260 | 2 | 7,760 | 2 | 12,000 | 2 | 12,300 | 2 | 15,800 | 2 | 8,570 | 2 |
| Mercury | u | 0.1 | u | 0.1 | u | 0.1 | u | 0.1 | u | 0.1 | u | 0.1 | u | 0.1 |
| Nickel | 23 | 1 | 21 | 1 | 28 | 1 | 26 | 1 | 18 | 1 | 13 | 1 | 22 | 1 |
| Zinc | 280 | 0.1 | 179 | 0.1 | 146 | 0.1 | 523 | 0.1 | 897 | 0.1 | 176 | 0.1 | 495 | 0.1 |
| Percent Solids ( % ) | 11.8 | n/a | 28.6 | n/a | 13.2 | n/a | 6.2 | n/a | 7.1 | n/a | 6.82 | n/a | 10.6 | n/a |
| **RADIOCHEM** (Units = pCi/g wet wt.) | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR | RESULT | ERR |
| Gross Alpha | 0.171 | 0.06 | 0.56 | 0.19 | x | x | x | x | x | x | 0.037 | 0.013 | 0.105 | 0.033 |
| Gross Beta | 3.17 | 0.16 | 4.39 | 0.35 | x | x | x | x | x | x | 2.677 | 0.068 | 2.097 | 0.084 |
| Gamma Nuclides | | | | | | | | | | | | | | |
| Ac-228 | 0.163 | 0.034 | y | y | x | x | x | x | x | x | y | y | y | y |
| Be-7 | y | y | y | y | x | x | x | x | x | x | y | y | y | y |
| Bi-212 | y | y | y | y | x | x | x | x | x | x | y | y | y | y |
| Bi-214 | 0.169 | 0.019 | 0.326 | 0.032 | x | x | x | x | x | x | y | y | y | y |
| Cs-137 | y | y | y | y | x | x | x | x | x | x | y | y | y | y |
| K-40 | 1.51 | 0.16 | y | y | x | x | x | x | x | x | 2.03 | 0.21 | 1.69 | 0.17 |
| Pb-212 | 0.096 | 0.011 | 0.177 | 0.018 | x | x | x | x | x | x | y | y | y | y |
| Pb-214 | 0.157 | 0.019 | 0.292 | 0.028 | x | x | x | x | x | x | 0.096 | 0.018 | 0.067 | 0.015 |
| Tl-208 | y | y | 0.057 | 0.015 | x | x | x | x | x | x | y | y | y | y |

TABLE 1, Pg. 3

| **SAMPLE SITE I.D. NO. >>>** (Units = mg/kg) | BIOIND-15 | | BIOIND-16 | | BIOIND-17 | | BIOIND-18 | | BIOIND-19 | | BIOIND-20 | | BIOIND-21 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **METALS** | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| Antimony | x | x | x | x | x | x | x | x | u | 2 | u | 2 | x | x |
| Arsenic | x | x | x | x | x | x | x | x | 22 | 2 | 7 | 2 | x | x |
| Beryllium | x | x | x | x | x | x | x | x | 1.1 | 0.1 | 2.1 | 0.1 | x | x |
| Cadmium | x | x | x | x | x | x | x | x | 1.9 | 0.1 | 13 | 0.1 | x | x |
| Calcium | x | x | x | x | x | x | x | x | 70,800 | 1,000 | 64,900 | 1,000 | x | x |
| Chromium, Total | x | x | x | x | x | x | x | x | 32.3 | 0.1 | 19 | 0.1 | x | x |
| Cobalt | x | x | x | x | x | x | x | x | 30.1 | 0.2 | 58.2 | 0.2 | x | x |
| Copper | x | x | x | x | x | x | x | x | 26.6 | 0.1 | 28.5 | 0.1 | x | x |
| Iron | x | x | x | x | x | x | x | x | 16,900 | 2.5 | 9,250 | 2.5 | x | x |
| Lead | x | x | x | x | x | x | x | x | 49.5 | 0.3 | 41.9 | 0.3 | x | x |
| Magnesium | x | x | x | x | x | x | x | x | 24,900 | 2 | 17,000 | 2 | x | x |
| Mercury | x | x | x | x | x | x | x | x | u | 0.1 | u | 0.1 | x | x |
| Nickel | x | x | x | x | x | x | x | x | 31 | 1 | 31 | 1 | x | x |
| Zinc | x | x | x | x | x | x | x | x | 262 | 0.1 | 1,270 | 0.1 | x | x |
| Percent Solids ( % ) | x | x | x | x | x | x | x | x | 3.61 | n/a | 1.3 | n/a | x | x |

| **RADIOCHEMISTRY** (Units = pCi/g wet wt.) | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross Alpha | 0.04 | 0.011 | 0.14 | 0.049 | 0.075 | 0.021 | 0.067 | 0.02 | 0.152 | 0.041 | 0.058 | 0.016 | 0.4862 | 0.0091 |
| Gross Beta | 0.775 | 0.029 | 2.91 | 0.14 | 2.697 | 0.079 | 3.29 | 0.081 | 2.45 | 0.11 | 1.583 | 0.049 | 5.56 | 0.25 |
| Gamma Radionuclides | | | | | | | | | | | | | | |
| Ac-228 | y | y | 0.151 | 0.036 | 0.126 | 0.036 | y | y | y | y | y | y | 0.6 | 0.17 |
| Be-7 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-212 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-214 | 1.1 | 0.3 | 0.163 | 0.021 | 0.143 | 0.022 | 0.113 | 0.017 | 0.103 | 0.024 | 0.194 | 0.03 | 0.49 | 0.1 |
| Cs-137 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| K-40 | y | y | 1.96 | 0.18 | 2.35 | 0.22 | 2.29 | 0.17 | y | y | y | y | y | y |
| Pb-212 | y | y | 0.059 | 0.011 | 0.05 | 0.011 | 0.0332 | 0.0085 | 0.048 | 0.014 | 0.055 | 0.016 | 0.257 | 0.058 |
| Pb-214 | y | y | 0.14 | 0.017 | 0.074 | 0.02 | 0.106 | 0.015 | 0.074 | 0.02 | 0.195 | 0.029 | 0.416 | 0.087 |
| Tl-208 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |

TABLE 1, Pg. 4

| **SAMPLE SITE I.D. NO. >>>** (Units = mg/kg) | BIOIND-22 | | BIOIND-23 | | BIOIND-24 | | BIOIND-25 | | BIOIND-26 | | BIOIND-27 | | BIOIND-28 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **METALS** | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| Antimony | x | x | x | x | x | x | x | x | u | 2 | u | 2 | u | 2 |
| Arsenic | x | x | x | x | x | x | x | x | u | 2 | u | 2 | 38 | 2 |
| Beryllium | x | x | x | x | x | x | x | x | 1.6 | 0.1 | 0.9 | 0.1 | 0.6 | 0.1 |
| Cadmium | x | x | x | x | x | x | x | x | 1.5 | 0.1 | 0.7 | 0.1 | 4 | 0.1 |
| Calcium | x | x | x | x | x | x | x | x | 67,900 | 1,000 | 38,300 | 200 | 93,300 | 1,000 |
| Chromium, Total | x | x | x | x | x | x | x | x | 25.6 | 0.1 | 21 | 0.1 | 224 | 0.1 |
| Cobalt | x | x | x | x | x | x | x | x | 29.6 | 0.2 | 32.1 | 0.2 | 39 | 0.2 |
| Copper | x | x | x | x | x | x | x | x | 34 | 0.1 | 19.9 | 0.1 | 323 | 0.1 |
| Iron | x | x | x | x | x | x | x | x | 18,300 | 2.5 | 25,100 | 2.5 | 43,300 | 2.5 |
| Lead | x | x | x | x | x | x | x | x | 29.3 | 0.3 | 11.9 | 0.3 | 368 | 0.3 |
| Magnesium | x | x | x | x | x | x | x | x | 8,040 | 2 | 6,220 | 2 | 15,500 | 2 |
| Mercury | x | x | x | x | x | x | x | x | u | 0.1 | u | 0.1 | u | 0.1 |
| Nickel | x | x | x | x | x | x | x | x | 31 | 1 | 18 | 1 | 825 | 1 |
| Zinc | x | x | x | x | x | x | x | x | 459 | 0.1 | 116 | 0.1 | 1,460 | 0.1 |
| Percent Solids (%) | x | x | x | x | x | x | x | x | 1.4 | n/a | 2.16 | n/a | 2.63 | n/a |

| **RADIOCHEMISTRY** (Units = pCi/g wet wt.) | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross Alpha | 0.96 | 0.31 | 0.38 | 0.18 | 0.096 | 0.047 | 0.276 | 0.085 | 0.064 | 0.019 | 0.06 | 0.021 | 0.253 | 0.044 |
| Gross Beta | 9.39 | 0.65 | 5.54 | 0.39 | 2.67 | 0.14 | 2.4 | 0.17 | 0.668 | 0.041 | 2.401 | 0.08 | 2.583 | 0.253 |
| Gamma Radionuclides | | | | | | | | | | | | | | |
| Ac-228 | y | y | 0.61 | 0.11 | 0.338 | 0.045 | 0.311 | 0.062 | y | y | 0.171 | 0.032 | y | y |
| Be-7 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-212 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-214 | 1.61 | 0.2 | 0.475 | 0.079 | 0.302 | 0.033 | 0.347 | 0.046 | 0.29 | 0.05 | 0.075 | 0.02 | 0.265 | 0.047 |
| Cs-137 | y | y | 0.416 | 0.047 | y | y | y | y | y | y | y | y | y | y |
| K-40 | y | y | y | y | 2.07 | 0.22 | y | y | y | y | 2.08 | 0.23 | y | y |
| Pb-212 | 0.81 | 0.11 | 0.363 | 0.049 | 0.108 | 0.015 | 0.184 | 0.024 | y | y | 0.045 | 0.012 | 0.123 | 0.024 |
| Pb-214 | 1.43 | 0.17 | 0.478 | 0.072 | 0.224 | 0.025 | y | y | 0.311 | 0.046 | y | y | 0.184 | 0.041 |
| Tl-208 | y | y | y | y | y | y | y | y | y | y | y | y | y | y |

TABLE 1, Pg. 5

| SAMPLE SITE I.D. NO. >>> (Units = mg/kg) | BIOIND-29 | | BIOIND-30 | | BIOIND-31 | | BIOIND-32 | | BIOIND-33 | | BIOIND-34 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **METALS** | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| Antimony | u | 2 | x | x | x | x | x | x | x | x | u | 2 |
| Arsenic | 10 | 2 | x | x | x | x | x | x | x | x | 4 | 2 |
| Beryllium | 0.6 | 0.1 | x | x | x | x | x | x | x | x | 1.9 | 0.1 |
| Cadmium | 2.3 | 0.1 | x | x | x | x | x | x | x | x | 3.1 | 0.1 |
| Calcium | 74,200 | 1,000 | x | x | x | x | x | x | x | x | 53,300 | 200 |
| Chromium, Total | 34.7 | 0.1 | x | x | x | x | x | x | x | x | 32 | 0.5 |
| Cobalt | 28.7 | 0.2 | x | x | x | x | x | x | x | x | 19.7 | 0.2 |
| Copper | 220 | 0.1 | x | x | x | x | x | x | x | x | 52 | 0.1 |
| Iron | 28,800 | 2.5 | x | x | x | x | x | x | x | x | 22,900 | 2.5 |
| Lead | 57.9 | 0.3 | x | x | x | x | x | x | x | x | 15 | 0.3 |
| Magnesium | 10,500 | 2 | x | x | x | x | x | x | x | x | 21,400 | 2 |
| Mercury | u | 0.1 | x | x | x | x | x | x | x | x | z | z |
| Nickel | 255 | 1 | x | x | x | x | x | x | x | x | 94 | 1 |
| Zinc | 1,760 | 0.1 | x | x | x | x | x | x | x | x | 609 | 0.1 |
| Percent Solids ( % ) | 1.11 | n/a | x | x | x | x | x | x | x | x | 0.83 | n/a |
| **RADIOCHEMISTRY** (Units = pCi/g wet wt.) | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR | RESULT | ERROR |
| Gross Alpha | 0.071 | 0.018 | 0.101 | 0.022 | 0.61 | 0.12 | 0.43 | 0.11 | 0.147 | 0.062 | 0.032 | 0.011 |
| Gross Beta | 1.16 | 0.045 | 0.797 | 0.042 | 7.56 | 0.28 | 6.37 | 0.27 | 4.34 | 0.2 | 2.347 | 0.055 |
| Gamma Radionuclides | | | | | | | | | | | | |
| Ac-228 | y | y | 0.99 | 0.28 | 0.161 | 0.025 | y | y | y | y | y | y |
| Be-7 | y | y | y | y | 3.03 | 0.17 | 1.5 | 0.11 | y | y | y | y |
| Bi-212 | y | y | y | y | y | y | y | y | y | y | y | y |
| Bi-214 | y | y | y | y | 0.151 | 0.02 | 0.067 | 0.012 | y | y | 0.089 | 0.024 |
| Cs-137 | y | y | y | y | y | y | y | y | y | y | y | y |
| K-40 | y | y | y | y | y | y | y | y | y | y | y | y |
| Pb-212 | y | y | y | y | 0.105 | 0.012 | 0.0415 | 0.0061 | 0.078 | 0.023 | y | y |
| Pb-214 | y | y | y | y | 0.146 | 0.018 | 0.067 | 0.011 | 0.146 | 0.035 | 0.09 | 0.021 |
| Tl-208 | y | y | y | y | y | y | 0.0217 | 0.0061 | 0.097 | 0.028 | y | y |

TABLE 1, Pg. 6

| SAMPLE SITE I.D. NO. >>> (Units = mg/kg) | BIOIND-35 | | BIOIND-36 | | BIOIND-37 | | BIOIND-38 | |
|---|---|---|---|---|---|---|---|---|
| METALS | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* | RESULT | MDL* |
| Antimony | x | x | u | 2 | u | 2 | x | x |
| Arsenic | x | x | 21 | 2 | u | 2 | x | x |
| Beryllium | x | x | 1.8 | 0.1 | 2 | 0.1 | x | x |
| Cadmium | x | x | 11.2 | 0.1 | 2.6 | 0.1 | x | x |
| Calcium | x | x | 55,500 | 400 | 58,900 | 400 | x | x |
| Chromium, Total | x | x | 27 | 0.1 | 23.5 | 0.1 | x | x |
| Cobalt | x | x | 8.7 | 0.2 | 12.9 | 0.2 | x | x |
| Copper | x | x | 33.4 | 0.1 | 26.7 | 0.1 | x | x |
| Iron | x | x | 14,900 | 2.5 | 13,800 | 2.5 | x | x |
| Lead | x | x | 31.3 | 0.3 | 7.3 | 0.3 | x | x |
| Magnesium | x | x | 18,700 | 2 | 17,300 | 2 | x | x |
| Mercury | x | x | z | z | z | z | x | x |
| Nickel | x | x | 46.5 | 1 | 27.7 | 1 | x | x |
| Zinc | x | x | 742 | 0.1 | 298 | 0.1 | x | x |
| Percent Solids ( % ) | x | x | 1.72 | n/a | 1.23 | n/a | x | x |
| RADIOCHEM (Units = pCi/g wet wt.) | RESULT | ERROR | RESULT | ERROR | RESULT | ERR | RESULT | ERR |
| Gross Alpha | 0.119 | 0.035 | 0.062 | 0.018 | 0.035 | 0.028 | 0.033 | 0.019 |
| Gross Beta | 5.14 | 0.12 | 4.575 | 0.087 | 5.07 | 0.12 | 5.6 | 0.11 |
| Gamma Radionuclides | | | | | | | | |
| Ac-228 | y | y | y | y | y | y | y | y |
| Be-7 | y | y | y | y | y | y | y | y |
| Bi-212 | y | y | y | y | y | y | y | y |
| Bi-214 | 0.252 | 0.062 | y | y | y | y | 0.279 | 0.06 |
| Cs-137 | y | y | y | y | y | y | y | y |
| K-40 | y | y | y | y | y | y | y | y |
| Pb-212 | y | y | y | y | y | y | y | y |
| Pb-214 | y | y | y | y | y | y | y | y |
| Tl-208 | y | y | y | y | y | y | y | y |

**TABLE 2**

| SAMPLE IDENT. | DOE Plant Site | SPRING NAME (CREEK NAME) | DATE SAMPLED | Lab Tests Performed | LATITUDE (NORTHING) | LONGIT. (WESTING) | MEDIA SAMPLED |
|---|---|---|---|---|---|---|---|
| BIOIND-01 | Y-12 | SS-2 Spring (West Bear Creek Valley) | 1/10/03 | Metals/ Rad | 35.9693 | -84.2813 | Watercress Nasturtium officinale |
| BIOIND-02 | ORNL | Burns Cemetery Spring | 1/29/03 | Metals/ Rad | 35.93068 | -84.33782 | Green Algae |
| BIOIND-03 | Y-12 | West Bear Creek Valley Seep | 1/29/03 | Metals/ Rad | 35.94553 | -84.32222 | Aquatic Waterweed = Sparganium sp. |
| BIOIND-04 | Ref. | Bacon Spring | 1/29/03 | Metals/ Rad | 36.05961 | -84.22526 | Watercress Nasturtium officinale ) |
| BIOIND-05 | ETTP | 21002 Spring (K-25 Site) | 2/3/03 | Metals/ Rad | 35.93869 | -84.41298 | Green Algae = Oedogonium Ulothrix Zygnema |
| BIOIND-06 | ETTP | USGS 10895 Spring | 2/3/03 | Metals/ Rad | 35.95279 | -84.3894 | Green Algae |
| BIOIND-07 | ETTP | USGS 10895 Spring | 2/3/03 | Metals/ Rad | 35.95279 | -84.3894 | Watercress Nasturtium officinale |
| BIOIND-08 | Ref. | Oak Ridge City Pool Spring | 2/3/03 | Metals/ Rad | 36.01566 | -84.26557 | Watercress Nasturtium officinale |
| BIOIND-09 | ETTP | Ebulient Spring | 2/5/03 | Metals/ Rad | 35.95521 | -84.39111 | Green Algae |
| BIOIND-10 | Y-12 | Aquarius Spring | 3/3/03 | Metals | 35.9721 | -84.2496 | Green Algae = Spirogyra Ulothrix Melosira |
| BIOIND-11 | Y-12 | Sadachbia Spring | 3/3/03 | Metals | 35.97151 | -84.2498 | Watercress Nasturtium officinale ) & Green Algae = Cladophora Spirogyra Ulothrix Oscillatoria |
| BIOIND-12 | Y-12 | Upper McCoy Branch | 3/3/03 | Metals | 35.97371 | -84.25045 | Watercress Nasturtium officinale |
| BIOIND-13 | Ref. | Reference Spring North (UT Arboretum) | 3/3/03 | Metals/ Rad | 36.00034 | -84.19743 | Watercress Nasturtium officinale |
| BIOIND-14 | Ref. | Reference Spring South (UT Arboretum) | 3/3/03 | Metals/ Rad | 36.00019 | -84.19762 | Watercress Nasturtium officinale |
| BIOIND-15 | ORNL | Gum Branch Spring | 3/6/03 | Rad | 35.96335 | -84.3154 | Watercress Nasturtium officinale & Green Algae = Tribonema |
| BIOIND-16 | ORNL | White Wing Spring | 3/6/03 | Rad | 35.95717 | -84.33811 | Mixed aquatic vegetation |
| BIOIND-17 | Y-12 | SS-6-East (West Bear Creek Valley) | 3/13/03 | Rad | 35.94823 | -84.31663 | *Aquatic Waterweed = Sparganium sp.* |
| BIOIND-18 | Y-12 | SS-6-West (West Bear Creek Valley) | 3/13/03 | Rad | 35.94779 | -84.31727 | Watercress Nasturtium officinale & Sparganium sp. |
| BIOIND-19 | Y-12 | SS-5.95 km Spring (West Bear Creek Valley) | 3/13/03 | Metals/ Rad | 35.9434 | -84.32541 | Watercress |
| BIOIND-20 | Ref. | Clear Creek Spring (Norris Watershed Ref. Site) | 3/14/03 | Metals/ Rad | 36.21611 | -84.05194 | Watercress Nasturtium officinale |
| BIOIND-21 | Ref. | Clear Creek Spring (Norris Watershed Ref. Site) | 3/14/03 | Rad | 36.21611 | -84.05194 | Green Algae = Tribonematales |
| BIOIND-22 | ORNL | Sycamore Spring | 3/14/03 | Rad | 35.91431 | -84.3376 | Green Algae = Spirogyra Ulothrix |
| BIOIND-23 | ORNL | Jones Island Creek | 3/24/03 | Rad | 35.90294 | -84.34299 | Green Algae |
| BIOIND-24 | ORNL | Raccoon Creek 1 | 3/24/03 | Rad | 35.902401 | -84.35184 | Aquatic Moss (Bryophyta) |

**TABLE 2 cont'd**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BIOIND-25 | ORNL | Raccoon Creek 2 | 3/24/03 | Rad | 35.903501 | -84.35048 | Aquatic plants |
| BIOIND-26 | ORNL | Walker Branch (south of Bethel Valley Rd.) | 4/28/03 | Metals/ Rad | 35.95278 | -84.27351 | Green filamentous algal bloom = Spirogyra Cladophora |
| BIOIND-27 | Ref. | Mill Branch Reference Site | 4/30/03 | Metals/ Rad | 35.98897 | -84.28936 | Watercress ( Nasturtium officinale ) |
| BIOIND-28 | ETTP | Mitchell Branch MIK-0.45 Downstream Site | 5/1/03 | Metals/ Rad | 35.93848 | -84.39039 | Watercress ( Nasturtium officinale ) and Mint ( Mentha sp. ) |
| BIOIND-29 | ETTP | Mitchell Branch MIK-0.71 Upstream Site | 5/1/03 | Metals/ Rad | 35.93773 | -84.38775 | Watercress ( Nasturtium officinale ) |
| BIOIND-30 | ETTP | Mitchell Branch - ditchline | 5/1/03 | Rad | 35.937801 | -84.38891 | Green Algae |
| BIOIND-31 | ETTP | K-1066-K UF-6 Cylinder Yard (Pool of water along fenceline) | 7/22/03 | Rad | 35.93701 | -84.41118 | Green Algae including (but not limited to) Nostoc |
| BIOIND-32 (REPLICATE of BIOIND-31) | ETTP | K-1066-K UF-6 Cylinder Yard (Pool of water along fenceline) | 7/22/03 | Rad | 35.93701 | -84.41118 | Green Algae including (but not limited to) Nostoc |
| BIOIND-33 | ETTP | K-25 Pond Outfall "SD-130" K-1007-P5 Pond | 7/28/03 | Rad | 35.92587 | -84.38736 | Green filamentous algal bloom |
| BIOIND-34 | ETTP | George Jones Spring (McKinney Ridge) | 8/19/03 | Metals/ Rad | 35.94214 | -84.37179 | Watercress ( Nasturtium officinale ) |
| BIOIND-35 | Ref. | Bootlegger Spring (UT Arboretum) | 12/2/03 | Rad | 35.99611 | -84.22279 | Watercress ( Nasturtium officinale ) |
| BIOIND-36 | Ref. | "Bootlegger North Spring" (UT Arboretum) | 12/2/03 | Metals/ Rad | 35.99662 | -84.22307 | Watercress ( Nasturtium officinale ) |
| BIOIND-37 | Ref. | "Ole House Pond Spring" (UT Arboretum) | 12/2/03 | Metals/ Rad | 35.99649 | -84.20333 | Watercress ( Nasturtium officinale ) |
| BIOIND-38 | Ref. | Periwinkle Spring (UT Arboretum) | 12/2/03 | Rad | 35.99518 | -84.20219 | Watercress ( Nasturtium officinale ) |

TABLE 3

| METALS (Drinking Water MCL) | Arsenic 0.05 ppm | Cadmium 0.005 ppm | Lead 0.05 ppm | Mercury 0.002 ppm | Nickel | Total Chromium 0.1 ppm | Zinc 5.0 ppm | Comments |
|---|---|---|---|---|---|---|---|---|
| SAMPLING LOCATION / SPRING NAME | | | | | | | | |
| Burns Cemetery Spring * (ORNL) | 0 | 0 | 0 | 0 | 0 | 0 | 0.005 | |
| 21002 Spring (K25)* | 0 | 0 | 0 | 0 | 0 | 0 | 0.008 | |
| USGS 10-895 Spring* | 0 | 0 | 0 | 0 | 0 | 0 | 0.007 | |
| Bootlegger Spring* | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 | |
| SS 5.95km Spring* | 0 | 0 | 0 | 0 | 0 | 0 | 0.007 | |

| RADIOLOGICAL | Gross Alpha (Limit: 15 pCi/L) | Gross Beta (Limit: 50 pCi/L) | Comments |
|---|---|---|---|
| | High / Low Values | High / Low Values | |
| Burns Cemetery Spring* (ORNL) | 0.1 / -0.9 | 1.8 / 1.1 | |
| 21002 Spring (K25)* | 3.6 / 0.8 | 20.7 / 1.7 | |
| USGS 10-895 Spring* | 1.0 / 0.2 | 1.5 / 0.3 | |
| Bootlegger Spring* | 1.3 / -0.8 | 0 / -0.1 | |
| SS 5.95km Spring* | 0.6 / 0.4 | 2 / -0.3 | |
| Aquarius Spring ** ( SCR3.5SP) | < MDA | 4.33 | MDA = Minimum Detectable Activity |

*(2002 TDEC spring groundwater data)

**(2002 BWXT Y12 spring groundwater data)

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# CHAPTER 5 RADIOLOGICAL MONITORING

## 2003 Mapping Invasive Plant Species on the 3000 Acre (Proposed) NRDA Land Transfer Parcel (Blackoak/McKinney Ridge)


### Abstract

The project was conceptualized during the summer of 2003 following public meetings held for the purpose of inviting the community to comment on the management plan for approximately 3,000 acres (See Figure 1) of federally-owned land on the Blackoak Ridge and McKinney Ridge areas of the Oak Ridge Reservation (ORR). This acreage has been proposed for inclusion in a conservation easement between the state of Tennessee and the Department of Energy (per a December 20, 2002 “Letter of Intent”) pursuant to the Natural Resources Damages Assessment (NRDA) as partial repayment for resource injuries to the Watts Bar Reservoir resulting from federal activities on the ORR. As an indirect result of public comment, the division determined to take a proactive role in establishing plant biodiversity of natural resources on this parcel (including the exotic species). Accordingly, fieldwork commenced in August 2003 (unrelated cursory field surveys had been done in 2002-03) and halted in late October 2003. Resumption of these field-mapping activities will continue in the spring of 2004. This project will incorporate the division’s role of environmental surveillance.


### Introduction

During 2003, public meetings (including local advocacy groups) were held for the purpose of inviting the community to comment on the management plan for approximately 3,000 acres (See Figure 1) of federally-owned land on the Blackoak Ridge and McKinney Ridge areas of the Oak Ridge Reservation (ORR). This acreage has been proposed for inclusion in a conservation easement between the state of Tennessee and the Department of Energy pursuant to the Natural Resources Damages Assessment (NRDA) as partial repayment for land resource damages incurred due to federal activities on the ORR. Some comments received advocated managing the site as a natural area. Prior to these events, the Tennessee Department of Environment and Conservation (TDEC) and the Department of Energy (DOE) signed a “Letter of Intent” on December 20, 2002, indicating that the area would be managed for conservation, research, and recreation. This conservation easement has been established by DOE pursuant to CERCLA (Superfund) as partial mitigation of natural resource damages (injuries) to the Clinch River and Watts Bar Reservoir. The agreement is not yet finalized as various agenda items remain to be discussed (such as the final boundary outline, etc.). DOE subcontractors have previously surveyed the area for vascular plants but some sections or habitats could have been missed. Accordingly, the division decided to utilize time in the interim to do an invasive/native plant species survey to more completely document the resource management needs of this easement parcel. Fieldwork commenced in August 2003 (unrelated cursory field surveys had been done in 2002-03) and halted in late October 2003. This project will incorporate the division’s role of environmental surveillance.

### Methods and Materials

In a large sense, this exotic/native plant survey will be a multi-faceted biodiversity, geological and historical field study. Field-mapping of native and invasive plant species on the 3000 acres will begin by first surveying the available roads and trails with individual field stations (mini-plots) at 100/200 meter intervals as needed. Unusual or rare plants will be located and mapped, if found between these intervals. Once roads and trails are mapped, then transects will be walked cross-country (similar to a "timber cruise") in generally north to south traverses. Later, if feasible, east-west traverses may be done to complete a grid pattern of coverage over the parcel. Selected habitats such as small drainage ravines/floodplains, wetlands, sub-watersheds, sinkholes, springs, caves, etc. will be located and mapped.

Each field station (mini-plot) will be mapped using a Global Positioning System (GPS) hand-held field unit. Each field station will be defined as a <u>50-foot circle from center point or circumference</u> (GPS location being the center point). As many plant species as possible within that 50-foot circle will be identified (common names & corresponding scientific names). This will include the canopy, sub-canopy, shrub, herb, and groundcover plant species. Ultimately, several permanent plots will be established throughout the parcel to monitor and list plant species in considerable detail (by layer – canopy, sub-canopy, shrub, etc.). The digital camera will be used to document plant species as well as pre-Manhattan cultural/historical features of the former Wheat community. Karst and geologic features such as springs, seeps, sinkholes, and caves will be logged and located with the GPS. If, by chance, any legacy waste (drums, trenches, etc.) or obvious signs of federal activity were to be observed in the backcountry, then these sites will be located and duly reported as well. Animal species sightings will also be noted. The boundaries of the pine deadfall areas will be mapped whenever possible in the field. These sites may become important ecological study areas to determine if native climax species or invasives will re-establish here. Ecology of the infested sites, including competition between established native species and invaders, and pine deadfall areas will be evaluated as to recovery and establishment of climax plant species. Are native plant species being extirpated by the invaders?

No analytical sampling of plant species is envisioned for this project. However, plant species will be collected for preservation of herbarium specimens. The sample will be collected as much as possible with either flower or fruit then pressed and dried, and mounted on herbarium paper with appropriate identification labels. These are quite useful for training purposes but more importantly to document plant species (especially rare species) encountered in the field.

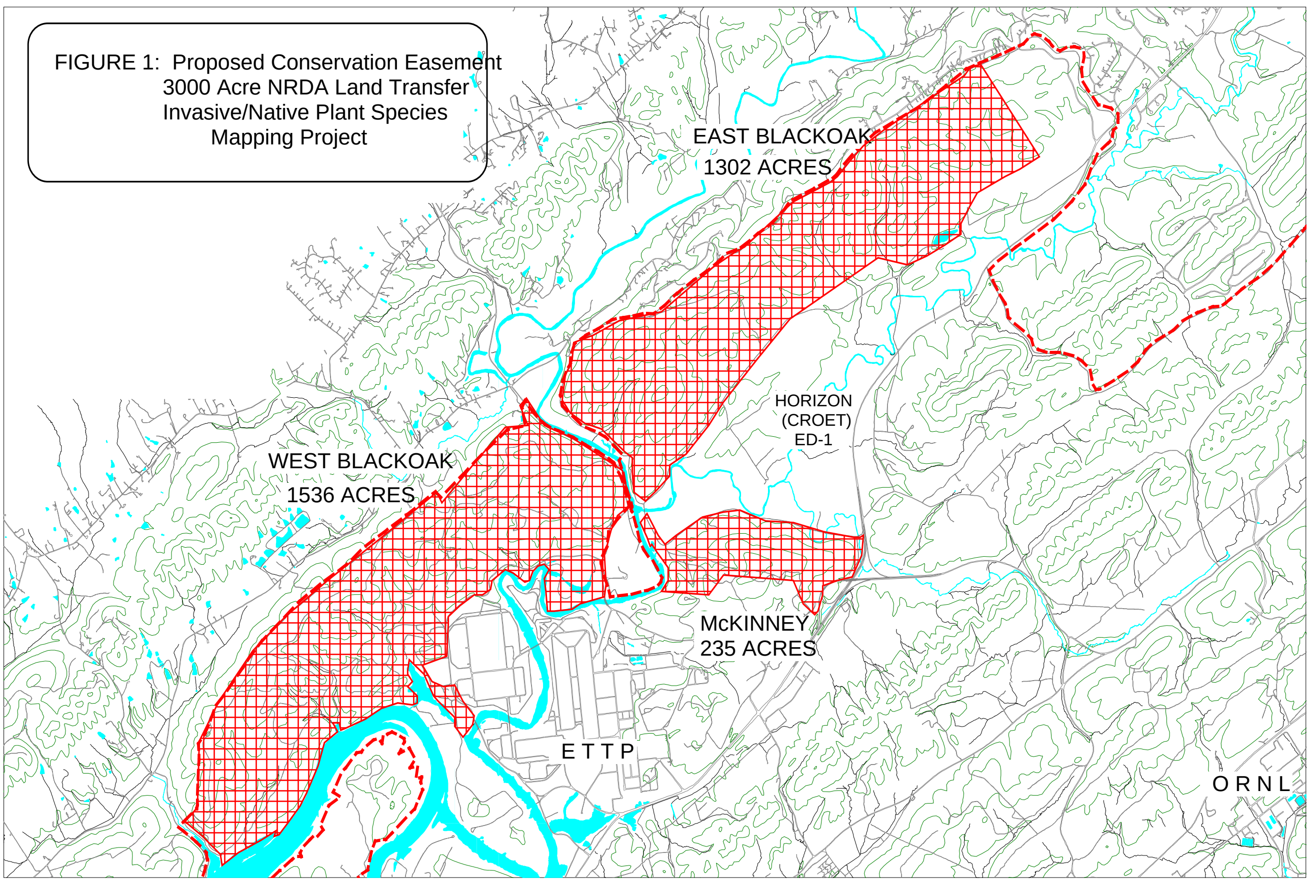
Field data sheets (field survey logs) will be recorded for each field station and later placed on an Excel spreadsheet database. Maps will be prepared with MapInfo to show locations of all field stations, geologic features, and other pertinent topographical information. Ultimately, plant species maps will be generated to show locations of the major exotic infestation sites. Sampling protocol and quality control methods will follow the guidelines in the division's "Standard Operating Procedures" and "Health, Safety, and Security Plan."

**<u>Results and Discussion</u>**

During late summer and fall of 2003, approximately 300 field data stations (See Figure 2) were inventoried (and database developed) per the methodology described under the "Methods and Materials" section. The main area covered during 2003 was the East Blackoak Ridge tract of ~1302 acres. The remaining two tracts of the 3000 acre parcel includes McKinney Ridge tract of ~235 acres and the West Blackoak tract of ~1536 acres (See Figure 1). Several exotic plant infested areas were identified on the East Blackoak Ridge tract. Some of the main pest plants identified so far infesting areas of Blackoak Ridge include: (1) Privet (*Ligustrum spp*. L.), (2) Nepalgrass (*Microstegium vimineum*), (3) Autumn Olive (*Elaeagnus umbellata*), (4) Kudzu

(*Pueraria montana*), (5) Wild Yam (*Dioscorea bulbifera* or *D. batatas*), Bush Honeysuckle (*Lonicera maackii*), (6) Japanese Honeysuckle (*Lonicera japonica*), and (7) Tree-of-Heaven (*Ailanthus altissima).* Figure 3 is an example of a plant density map (thematic map) demonstrating areas infested with Kudzu and Privet plants on the study parcel. Please note that the "dark-shaded circles" on the map represent Kudzu infested areas, "lighter-shaded circles" represent Privet infested areas, and the small "stars" represent field inventory stations (survey data points). Future division reports will contain additional plant (species) density maps covering the entire 3000 acres.

**FIGURE 1: 3000 ACRE PROPOSED CONSERVATION EASEMENT LAND GRANT**



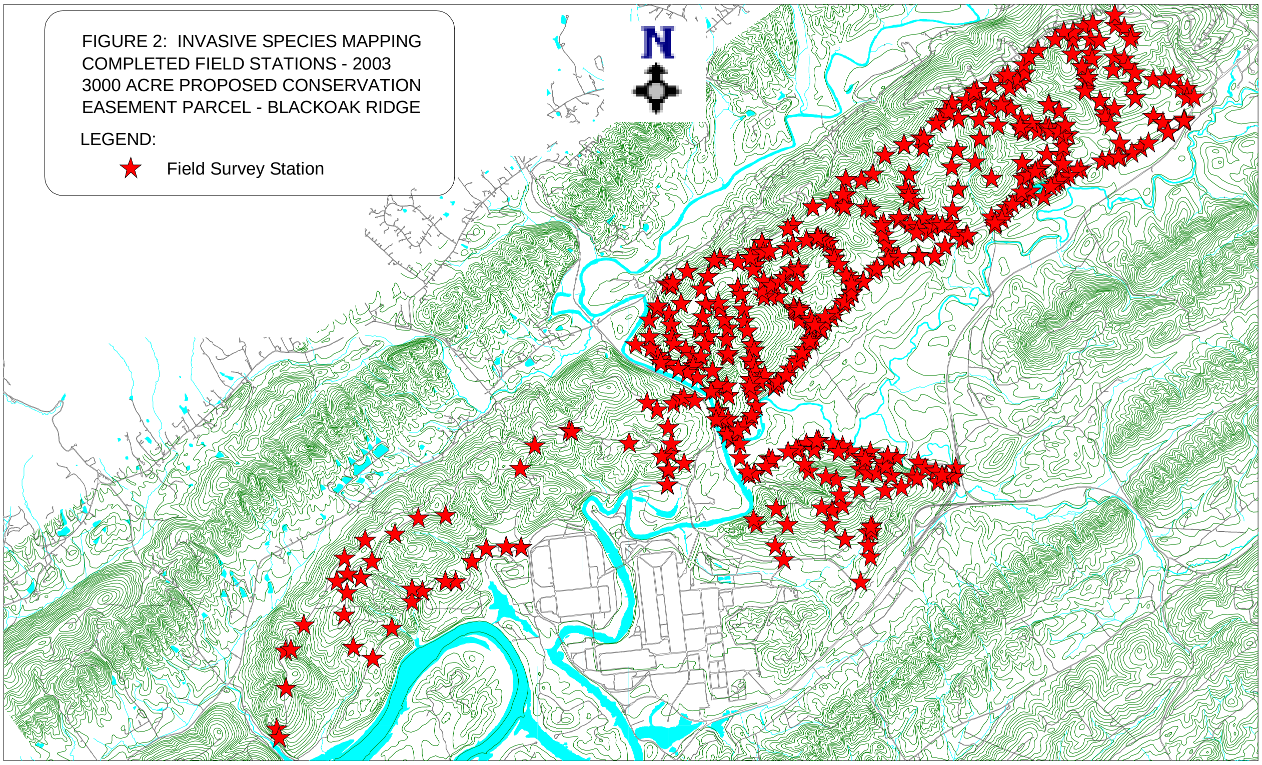


FIGURE 2: INVASIVE SPECIES MAPPING
COMPLETED FIELD STATIONS - 2003
3000 ACRE PROPOSED CONSERVATION
EASEMENT PARCEL - BLACKOAK RIDGE
LEGEND:
Field Survey Station
N

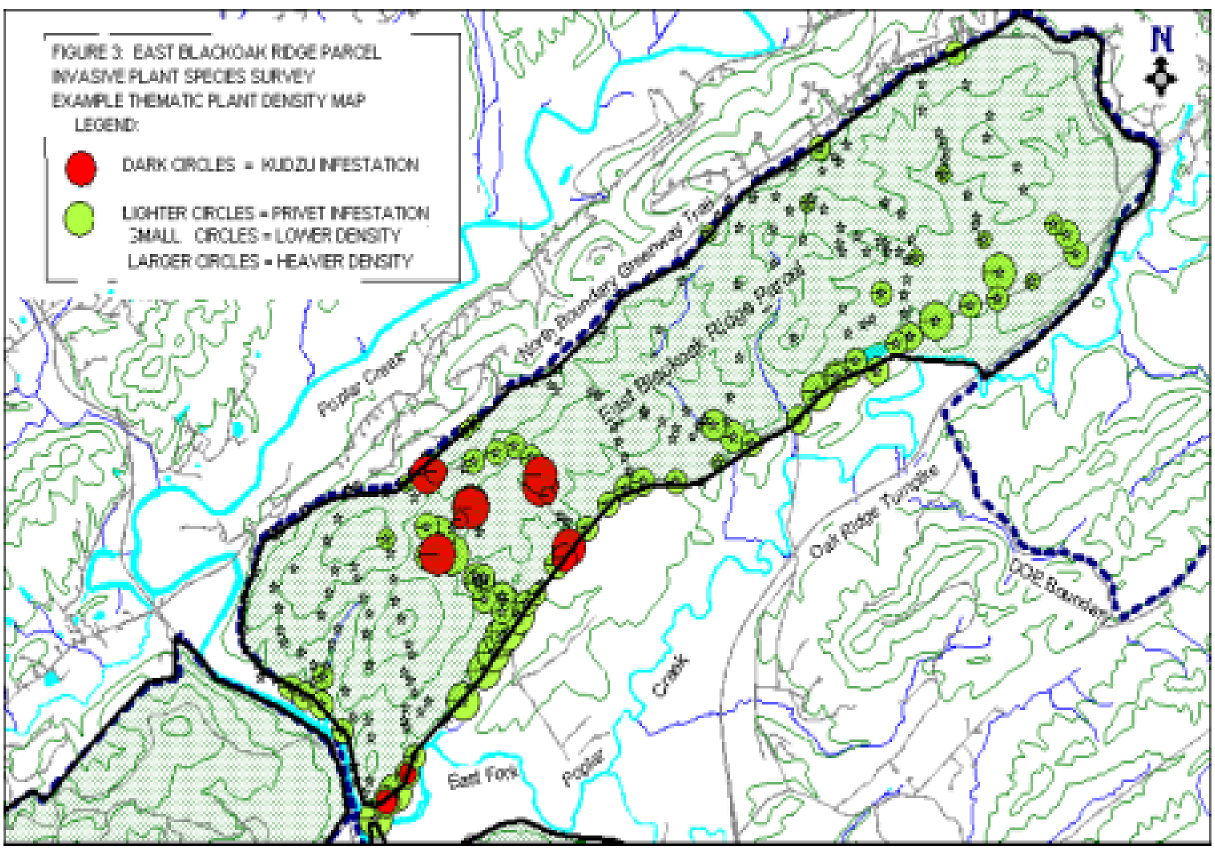


FIGURE 3: EAST BLACKOAK RIDGE PARCEL
INVASIVE PLANT SPECIES SURVEY
EXAMPLE THEMATIC PLANT DENSITY MAP
LEGEND:
DARK CIRCLES = KUDZU INFESTATION
LIGHTER CIRCLES = PRIVET INFESTATION
SMALL CIRCLES = LOWER DENSITY
LARGER CIRCLES = HEAVIER DENSITY
N
North Boundary Greenway Trail
East Blackoak Ridge Parcel
Poplar Creek
Oak Ridge Turnpike
DOE Boundary
Creek
East Fork
Poplar

## Conclusions

Since this was an un-planned project for 2003 (not included in the 2003 Environmental Monitoring Plan) and much of the fieldwork is yet incomplete (only about 40% finished), results will be covered in more detail in the 2004 Environmental Monitoring Report. Resumption of field-mapping activities will commence in the spring of 2004. From this initial mapping effort, we observed that the majority of the exotic species occur along existing gravel roads, pine-beetle damaged pine plantations, and formerly disturbed sites. Here, the exotics have little competition for habitat space. However, in the case of Kudzu infestations it does not seem to matter about competition from native plants as this aggressive invader takes over all vegetation (living or dead), open space, etc. There are, however, infested locations in the backcountry away from roads or trails.

## References


Awl, D. J. June 1996. *Survey of Protected Vascular Plants on the Oak Ridge Reservation, Oak Ridge*, *Tennessee*. ORNL-Environmental Restoration Division. Lockheed Martin Energy Systems. ES/ER/TM-194.

Carman, Jack B. 2001. *Wildflowers of Tennessee*. Highland Rim Press, Tullahoma, Tennessee.

Cranfill, Ray. July 1980. *Ferns and Fern Allies of Kentucky*. Kentucky Nature Preserves Commission – Scientific & Technical Series – No. 1.

Drake, Sara J., et al. March 2003*. Assessment of Non-Native Invasive Plant Species on the U.S. DOE Oak Ridge National Environmental Research Park.* Castanea 68(1): 15-30.

Tennessee Department of Environment and Conservation, *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* 2001. Oak Ridge, Tennessee.

EPA Region IV, May 1996. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual,* Atlanta, Georgia.

Gleason, H.A. & Cronquist, A. 1991. *Manual of Vascular Plants of Northeastern United States and Adjacent Canada.* The New York Botanical Garden, Bronx, New York.

Radford, A.E., et al. 1968. *Manual of the Vascular Flora of the Carolinas*. The University of North Carolina Press, Chapel Hill, North Carolina.

Smith, R. M. 1998. *Wildflowers of the Southern Mountains*. The University of Tennessee Press, Knoxville, Tennessee.

Tennessee Exotic Pest Plant Council. April 2002. *Invasive Exotic Pest Plants in Tennessee*. Journal of the Tennessee Academy of Science 77(2): 45-48.

U. S. Army Corps of Engineers. November 1995. *Wetlands Delineation Manual.* http://www.wetlands.com/coe/87manp1a.htm

U. S. Department of Energy. Oak Ridge National Laboratory Environmental Sciences Division. April 2001. *Biological Monitoring and Abatement Program (BMAP).* http://www.esd.ornl.gov/BMAP

Wofford, B. E. 1989. *Guide to the Vascular Plants of the Blue Ridge*. The University of Georgia Press, Athens, Georgia.

Wofford, B. E. and E. W. Chester. 2002. *Guide to the Trees, Shrubs, and Woody Vines of Tennessee*. The University of Tennessee Press. Knoxville, Tennessee.

Yard, C. R., 2002. *Health, Safety and Security Plan.* Tennessee Department of Environment & Conservation, DOE-Oversight Division. Oak Ridge, Tennessee.

# CHAPTER 5 <u>RADIOLOGICAL MONITORING</u>

## Facility Survey Program

Principal Author: David Thomasson

**<u>Abstract</u>**

Like other Department of Energy research facilities across the nation, the Oak Ridge Reservation released large quantities of chemical and radiological contamination into the surrounding environment during nearly five decades of nuclear weapons research and development. In response to this history, the Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division) developed a Facility Survey Program to document the histories of facilities on the Reservation. The Program looks at facilities' physical condition, inventories of hazardous chemical and radioactive materials, process history, levels of contamination, and present-day potential for release of contaminants to the environment under varying conditions ranging from catastrophic (i.e. tornado) to normal everyday working situations. This broad-based assessment supports the objectives of Section 1.2.3 of the *Tennessee Oversight Agreement*, which was designed to inform local citizens and governments of the historic and present-day character of all operations on the Reservation. This information is also essential for local emergency planning purposes. Since 1994 the division's survey team has characterized 172 facilities and found that thirty five percent pose a relatively high potential for release of contaminants to the environment. In many cases, this high-potential-for-release relates to legacy contamination that escaped facilities through degraded infrastructures over decades of continual industrial use (e.g. leaking underground waste lines, substandard sumps and tanks, or ventilation ductwork). During 2003 the survey team evaluated four facilities and found that all four posed a high potential for environmental release. All four of these facilities were at Y-12 (9731, 9959, 9736, 9959-2). Staff also completed surveys of five additional facilities at Y-12 during 2003, but the final reports on these facilities are being held by Y-12 pending Official Use Only (OUO) classification discussion and review (9610, 9720-8, 9720-21, 9720-16, 9720-53). Consequently, these five facilities are not reported or recorded in this report. Since the inception of the program, DOE corrective actions (including demolitions) have removed ten facilities from the division's list of "high" Potential Environmental Release (PER) facilities.

Beginning in 2002 the Facility Survey Program staff also began organized document reviews and visits to facilities that were targeted for demolition at the ORNL and Y-12. This activity was in response to formal, accelerated infrastructure reduction (demolition) programs at each of those sites. During 2003 staff made 269 visits before and during the demolition of 67 facilities.

**<u>Introduction</u>**

The Tennessee Department of Environment and Conservation's Department of Energy Oversight Division (the division), in cooperation with the Department of Energy (DOE) and DOE contractors, conducts a Facility Survey Program (FSP) on the Oak Ridge Reservation (ORR). The program provides a comprehensive independent assessment of active and inactive facilities on the reservation based on their: (1) physical condition (2) inventories of radiological materials and hazardous chemicals (3) levels of contamination; and (4) operational history. The ultimate goal of the program is to fulfill the commitments agreed to by the state of Tennessee and the Department of Energy in Section 1.2.3 of the Tennessee Oversight Agreement, which states that *"Tennessee will pursue the initiatives in attachments A, C, E, F, and G. The general intent of these action items is to continue Tennessee's: (1) environmental monitoring, oversight and environmental restoration programs; (2) emergency preparedness programs; and (3) delivery of a better understanding to the local governments and the public of past and present operations at the ORR and potential impacts on the human health and/or environment by the ORR."* **The overall objective of the Facility Survey Program is to provide a detailed assessment of all potential hazards affecting or in any way associated with facilities on the Oak Ridge Reservation.** To this end, the program evaluates facilities' potential for release of contaminants to the environment under varying environmental conditions ranging from catastrophic (i.e. tornado, earthquake) to normal everyday working situations. This information is also essential for proper emergency preparedness planning.

**Methods, Materials and Evaluating the Potential for Environmental Release (PER)**

Survey program staff takes a historical research approach to evaluating each facility. Prior to commencing fieldwork they examine engineering documents, past contaminant release information, hazard-screening documents, drain databases, and radiological and chemical inventory data. They then perform a walk-through of the facility with the facility manager to gather interview information and to validate previously reviewed documents. During the walk-through, calibrated radiation survey instruments are used to estimate radiation contamination and dose levels. At the end of the document review and walk-through process, a final report is produced and information is entered into the division's Potential for Environmental Release (PER) database. This database helps the team characterize conditions at each facility based on its physical condition and potential for release of contaminants to the environment.

The PER database is composed of 10 "categories" that relate directly to the contents and condition of the operational infrastructure within and around each facility (Table 1). Each category is assigned a score from 0 to 5 (5 reflects the greatest potential) for each of the 10 "categories" (Table 2). As facilities are scored, totaled, and compared with each other, a relative ranking emerges. Special circumstances, such as legacy releases and professional judgment also influence category scoring. Scores are **not intended to reflect human health risk.** Rather, their sole purpose is to characterize facilities based on the conditions in and around them. This information is used within the division for information, comparison, and review purposes only.

The final facility survey report notifies DOE of the division's findings so that DOE has the opportunity to respond and formulate corrective actions. When the division receives written confirmation from DOE of corrective actions taken on a specific facility, the ranking for that facility is modified accordingly. The 10 "categories" that are scored and the "scoring criteria" are presented below in Tables 1 and 2. Table 3 provides a program summary.

**Table 1: Categories to be Scored**

| | |
|---|---|
| **1.** | Sanitary lines, drains, septic systems |
| **2.** | Process tanks, lines, and pumps |
| **3.** | Liquid Low-level Waste tanks, lines, sumps, and pumps |
| **4.** | Floor drains and sumps |
| **5.** | Transferable radiological contamination |
| **6.** | Transferable hazardous materials contamination |
| **7.** | Ventilation ducts and exit pathways to create outdoor air pollution |
| **8.** | Ventilation ducts and indoor air/building contamination threat |
| **9.** | Radiation exposure rates inside the facility escalated |
| **10.** | Radiation exposure rates outside the facility escalated |

**Table 2: Potential Environmental Release Scoring Guidelines**

| **Score** | Score is based on observations in the field and the historic and present-day threat of contaminant release to the environment/building and/or ecological receptors. |
|---|---|
| **0** | **No potential**: no quantities of radiological or hazardous substances present. |
| **1** | **Low potential**: minimal quantities present, possibility of an insignificant release, very small probability of significant release, modern maintained containment. |
| **2** | **Medium potential**: quantities of radiological or hazardous subs. present, structures stable in the near to long term, structures have integrity but are not state-of-the-art, adequate maintenance. |
| **3** | **Medium potential**: structures unstable, in disrepair, containment failure clearly dependent on time, integrity bad, maintenance lacking, containment exists for the short term only. |
| **4** | **High potential**: quantities of radiological or hazardous subs. present. Containment for any period of time is questionable; migration to environment has not started. |
| **5** | **Release**: radiological or hazardous substance containment definitely breached, environmental/interior pollution from structures detected, radiological and/or hazardous substances in inappropriate places like sumps/drains/floors, release in progress, or radiological exposure rates above Nuclear Regulatory Commission (NRC) guidance. |
| Note: A score of 0 or 1 designates a low Potential Environmental Release rank; a score of 2 or 3 designates a moderate rank; a score of 4 or 5 designates a high rank. | |

## Discussion and Results

The Facility Survey Program entered its tenth year in January 2003. As in previous years, inter-agency staff cooperation was excellent, which facilitated the flow of information related to corrective actions, changes in facility status or mission, decommissioning and decontamination activities, and onsite professional activities. During 2003 the survey program's Y-12 representative spent approximately one half of his time at the Y-12 site. This presence greatly enhanced program activities at that site.

In accordance with past division policy, an individual survey conducted on a facility at K-25 that has been leased to private industry might only address those portions of the facility that are leased. Consequently, some older reports may not include adjacent areas in the same facility or related facilities. These adjacent areas and related facilities may be contaminated and/or exhibit safety problems that are not reflected in the report. Therefore, when reviewing these reports, it is important to look for the phrase "leased area of the facility." This phrase indicates that the survey report covers only the leased area of the facility, specifically, and is not intended to assess the entire facility or related facility problems (such as drain lines) that may exist outside of the leased area.

Since program staff is continually in the process of evaluating DOE corrective actions taken to address facility concerns, any current ranking may not reflect the most recent corrective actions. Since the inception of the FSP, corrective actions (including demolition) have removed ten facilities (X-3525, X-7823-A, X-7827, X-7819, X-3505, K-1098-F, K-1200-C, Y-9404-3, Y-9208, Y-9620-2) from the division's list of "high" Potential Environmental Release facilities.

In 2003 the team surveyed four facilities at Y-12 (9731, 9959, 9736, 9959-2). All four of these were ranked as having a "high" Potential for Environmental Release. Staff also completed surveys of five additional facilities at Y-12 during 2003, but the final reports on these facilities are being held by Y-12 pending Official Use Only (OUO) classification discussions/issues (9610, 9720-8, 9720-21, 9720-16, 9720-53). Consequently, these five facilities are not reported or recorded in this report.

**Table 3: Facility Survey Program Summary**

| | **Totals** | **High PER Facilities** | **Removed High PER** | **Facilities Resurveyed** | **Demolition Visits** |
|---|---|---|---|---|---|
| A.: Facilities surveyed 1994 | 15 | 9 | 0 | 0 | 0 |
| B.: Facilities surveyed 1995 | 35 | 11 | 0 | 0 | 0 |
| C.: Facilities surveyed 1996 | 34 | 9 | 0 | 0 | 0 |
| D.: Facilities surveyed 1997 | 23 | 8 | 0 | 0 | 0 |
| E.: Facilities surveyed 1998 | 8 | 3 | 1 | 2 | 0 |
| F.: Facilities surveyed 1999 | 14 | 3 | 0 | 0 | 0 |
| G.: Facilities surveyed 2000 | 14 | 5 | 3 | 0 | 0 |
| H.: Facilities surveyed 2001 | 17 | 8 | 1 | 1 | 0 |
| I.: Facilities surveyed 2002 | 8 | 5 | 5 | 0 | 90 |
| J.: Facilities surveyed 2003 | 4 | 4 | 0 | 0 | 236 |
| K.: Totals | **172** | **61** | **10** | **3** | **326** |

**Description of the 57 Highest Scoring Facilities** (1994-03)
The PER database attempts to reflect the overall condition of a facility. However, it is not the total score of the 10 categories that is always the best indicator of potential for environmental release. Rather, what appears to be the most accurate indicator is the number of categories for which a facility scores a four or five (Table 1). Of the 172 facilities scored since 1994, 61 stood-out with one or more categories scoring a four or five (Table 4). Ten of these facilities have been removed through corrective actions or demolition. The following 57 high-scoring facilities are arranged in descending order of total numbers of fours and fives in the PER database.

## Table 4: Potential for Environmental Release for 57 High Scoring Facilities

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | DRAIN | TANKS | TANKS | SUMPS | TRANSF | TRANSF | VENT TO | VENT | INT. EXP. | O. EXP. | NUMBER | SURVEY |
| | LINES | LINES | LINES | DRAINS | RAD. | HAZ. | OUTSIDE | INSIDE | RAD. | RAD. | OF | YEAR |
| **BUILDING** | SANI. | PROC. | LLLW | FLOOR | CONT. | CONT. | AIR | SYSTEM | SURVEY | SURVEY | 4 and 5's | |
| X3028 | 0 | 4 | 4 | 3 | 4 | 4 | 4 | 5 | 5 | 3 | 7 | 1997 |
| Y9731 | 4 | 5 | 1 | 4 | 3 | 5 | 5 | 5 | 3 | 2 | 6 | 2003 |
| K1037-C | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 5 | 5 | 4 | 6 | 1998 |
| K1025-A | 0 | 0 | 0 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 6 | 1995 |
| Y9401-2 | 1 | 4 | 1 | 4 | 1 | 5 | 4 | 4 | 1 | 0 | 5 | 2001 |
| Y9204-3 | 3 | 5 | 2 | 3 | 4 | 5 | 4 | 4 | 2 | 1 | 5 | 2000 |
| X3019-B | 2 | 2 | 5 | 3 | 2 | 3 | 4 | 4 | 4 | 4 | 5 | 1995 |
| K633 | 3 | 5 | 1 | 4 | 5 | 5 | 2 | 5 | 4 | 5 | 5 | 2002 |
| K1004-B | 5 | 0 | 0 | 5 | 2 | 5 | 2 | 5 | 2 | 0 | 4 | 2001 |
| K1004-A | 5 | 0 | 0 | 5 | 2 | 5 | 2 | 5 | 2 | 0 | 4 | 2001 |
| X7700 | 4 | 0 | 0 | 3 | 5 | 4 | 2 | 2 | 3 | 5 | 4 | 1996 |
| X7700C | 4 | 4 | 0 | 4 | 2 | 1 | 2 | 0 | 0 | 4 | 4 | 1996 |
| Y9201-4 | 2 | 5 | 0 | 2 | 2 | 4 | 5 | 5 | 2 | 1 | 4 | 1998 |
| K1015 | 5 | 0 | 5 | 0 | 5 | 5 | 2 | 2 | 2 | 1 | 4 | 2002 |
| K1004-J | 5 | 5 | 0 | 4 | 3 | 0 | 0 | 0 | 1 | 1 | 3 | 2000 |
| Y9203 | 4 | 2 | 0 | 4 | 2 | 4 | 2 | 2 | 2 | 0.5 | 3 | 1995 |
| X2545 | 0 | 3 | 5 | 0 | 4 | 2 | 3 | 0 | 0 | 4 | 3 | 1995 |
| K1200-C | 1 | 3 | 0 | 1 | 3 | 5 | 2 | 4 | 3 | 4 | 3 | 1995 |
| Y9769 | 1 | 1 | 0 | 4 | 4 | 2 | 1 | 2 | 4 | 2 | 3 | 1995 |
| K1025-B | 0 | 0 | 0 | 2 | 5 | 2.5 | 3 | 2 | 4 | 5 | 3 | 1996 |
| X3020 | 0 | 0 | 5 | 5 | 5 | 0 | 2 | 0 | 0 | 1 | 3 | 1997 |
| X3108 | 0 | 0 | 5 | 5 | 5 | 0 | 2 | 2 | 2 | 2 | 3 | 1997 |
| X3091 | 0 | 0 | 5 | 5 | 5 | 1 | 2 | 2 | 3 | 2 | 3 | 1997 |
| K1004-E | 5 | 0 | 0 | 5 | 2 | 5 | 3 | 0 | 2 | 0 | 3 | 2002 |
| Y9616-3 | 0 | 2 | 0 | 4 | 2 | 4 | 1 | 1 | 1 | 1 | 2 | 2002 |
| Y9738 | 2 | 0 | 0 | 4 | 2 | 4 | 1 | 1 | 2 | 1 | 2 | 2002 |
| Y9743-2 | 0 | 3 | 0 | 5 | 3 | 5 | 2 | 2 | 2 | 1 | 2 | 2001 |
| X3592 | 0 | 3 | 3 | 2 | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 2001 |
| X3504 | 1 | 3 | 0 | 4 | 5 | 0 | 2 | 1 | 2 | 2 | 2 | 2001 |
| X2531 | 1 | 1 | 2 | 1 | 5 | 2 | 2 | 1 | 2 | 4 | 2 | 2001 |
| Y9213 | 3 | 1 | 5 | 3 | 3 | 5 | 1 | 1 | 1 | 1 | 2 | 2000 |
| X7720 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 2 | 1996 |
| X3001 | 3 | 1 | 2 | 3 | 3 | 2 | 4 | 4 | 3 | 3 | 2 | 1995 |
| K1200-S | 2 | 3 | 0 | 3 | 3 | 2 | 3 | 4 | 2.5 | 4 | 2 | 1995 |
| X7701 | 4 | 3 | 0 | 4 | 2 | 0 | 2 | 0 | 0 | 3 | 2 | 1996 |
| X7706 | 4 | 3 | 0 | 4 | 2 | 0 | 2 | 2 | 2 | 2 | 2 | 1996 |
| X7707 | 4 | 0 | 0 | 4 | 2 | 3 | 2 | 2 | 0 | 0 | 2 | 1996 |
| Y9736 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 3 | 0 | 0 | 1 | 2003 |
| Y9959-2 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 1 | 0 | 1 | 2003 |
| Y9959 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 1 | 0 | 1 | 2003 |

**Table 4: Potential for Environmental Release for 57 High Scoring Facilities cont'd**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | DRAIN | TANKS | TANKS | SUMPS | TRANSF | TRANSF | VENT TO | VENT | INT. EXP. | O. EXP. | NUMBER | SURVEY |
| | LINES | LINES | LINES | DRAINS | RAD. | HAZ. | OUTSIDE | INSIDE | RAD. | RAD. | OF | YEAR |
| **BUILDING** | SANI. | PROC. | LLLW | FLOOR | CONT. | CONT. | AIR | SYSTEM | SURVEY | SURVEY | 4 and 5's | |
| X3085 | 1 | 4 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 1 | 1994 |
| X7602 | 0 | 2 | 0 | 2 | 4 | 2 | 1 | 3 | 2 | 1 | 1 | 1997 |
| K1220-N | 0 | 2 | 0 | 0 | 3 | 2 | 2 | 4 | 2 | 3 | 1 | 1995 |
| X3002 | 0 | 2 | 0 | 2 | 3 | 1 | 2 | 3 | 4 | 1 | 1 | 1996 |
| Y9210 | 1 | 0 | 0 | 4 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1995 |
| Y9224 | 1 | 0 | 0 | 4 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1995 |
| Y9211 | 1 | 0 | 0 | 4 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1995 |
| Y9207 | 2 | 0 | 0 | 1 | 1 | 4 | 3 | 1 | 1 | 0 | 1 | 1995 |
| X7055 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1997 |
| X7700-B | 0 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 4 | 1 | 1996 |
| K1401-L3 | 1 | 0 | 0 | 1 | 4 | 2 | 1 | 2 | 3 | 1 | 1 | 1997 |
| Y9201-3 | 2 | 1 | 0 | 2 | 3 | 5 | 2 | 2 | 2 | 1 | 1 | 1999 |
| *X7819 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1994 |
| *****X3505 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2000 |
| *Y9620-2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1994 |
| *Y9208 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1995 |
| *Y9404-3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1994 |

* Denotes demolished facility

At **Y-12** eighteen facilities had at least one category score of 4 or 5: 9731, 9204-3, 9201-4, 9401-2, 9213, 9743-2, 9203, 9769, 9201-3, 9616-3, 9738, 9210, 9224, 9211, 9207, 9959, 9736, and 9959-2.

Facility Y-9731 is the oldest facility in the Y-12 complex. It originally housed the pilot project for the prototype calutron, and the original production facilities for stabilized metallic isotopes, which were used in nuclear medicine. It received four category scores of 5, two category scores of 4, and a total of 37. Most of the facility (outside the office area) today is not receiving preventative maintenance. Process tanks and lines have leaked radiological and hazardous materials throughout the building. Asbestos-containing pipe insulation is peeling and flaking, as is lead-bearing interior and exterior paint. The exhaust fans for the building are not HEPA filtered, and therefore pose a direct pathway to the environment.

Facility Y-9204-3 (Beta 3) is one of the original isotope enrichment facilities at Y-12. It received two category scores of 5, three category scores of 4, and a total score of 33. This 250,000sq. ft. facility is now inactive and locked. The largest concerns are leaking PCB-contaminated mineral oil (Z-oil), and radiological contamination. The building has not been sampled above eight feet for radiological contamination, even though the probability of finding it is great. The building historically and presently vents directly to the environment without HEPA filtration.

Facility Y-9201-4 (Alpha 4) is also one of the original Y-12 uranium enrichment buildings. It received three category scores of 5, one category score of 4, and a total of 28. The containment integrity of the original process system is weak. This has resulted in breaches that have deposited contaminants in unwanted places throughout the building. Evidence suggests that open (non-filtered) exhaust fans have also released contaminants from the interior of the building to the environment for decades. PCBs, asbestos insulation, and chipping/flaking lead-based paint are also found deposited throughout the building.

Facility Y-9401-2 (Plating Shop) received four category scores of 4, one category score of 5, and a total of 25. All of these scores relate to a variety of chemical contamination issues.

Facility Y-9213 (Criticality Experiment Facility) received two category scores of 5, and a total of 24. This facility was built in 1951 and contains two underground neutralization tanks and an underground pit. The tanks and pit present a very high potential for radiological and chemical soil contamination. The areas around the tanks have not been sampled for contamination. The facility also exhibits extensive flaking of exterior lead-based paint.

Facility Y-9743-2 (Animal Quarters) received two category scores of 5, and a total of 20. These scores reflect the uncertainty associated with the lack of radiological and chemical sampling surveys, the complete lack of institutional and process knowledge and, the fact that there are interior tanks and bottles with unknown contents. The probability of biological and chemical contamination is high. There is also a total lack of facility maintenance.

Facility Y-9203 (Instrumentation, Characterization Department and Manufacturing Technology Development Center) has three category scores of 4 and a total score of 22.5. Despite much work that has been done to re-route process drains from terminating in the storm sewer system, these drains now go to the sanitary sewer system. This termination still presents a potential pathway to the environment and the public.

Facility Y-9769 (Analytical Services Organization) has three category scores of 4 and a total score of 21. The primary hazards associated with this facility are related to the wide variety of toxic materials maintained in the laboratory and the building's drain destination. Exit drains go to the Oak Ridge Sewage Treatment Facility and therefore represent a pathway for contaminants to the city's effluent and/or sludge. Also, the sub-basement area is posted as a contamination area and confined space. Failure of containment could cause a release to East Fork Poplar Creek or to the atmosphere.

Facility Y-9201-3 (Alpha 3) received one category score of 5, and a total of 20. This facility is not receiving any maintenance on its exterior painted surface. Lead based paint is chipping and is being spread extensively around the building.

**<u>Facility Y-9616-3 received two category scores of 4 because of extensive interior and exterior peeling lead-based paint, and degraded asbestos-containing wall coverings and pipe insulation. The building is not receiving maintenance. There is a serious loss of process knowledge.</u>**

Facility Y-9738 received two category scores of 4, and a total of 17. This building contains foundry machinery and furnaces and spaces that are chemically and radiologically contaminated from past operations. It is assumed that some of this material has moved into the floor drain system. There is also extensive exterior paint peeling. There was a very limited knowledge of process history available to staff.

Facilities Y-9210, Y-9211, Y-9224 (ORNL Biology) each had one category score of 4 with a total score of 11 for each facility. The original concern regarding each of these facilities was the questionable terminal destinations of their exit drains, which in some cases historically went to the storm sewer system. Written confirmation from the DOE contractor has since shown the correct terminations and corrective actions taken on some of these drains, but there are still undefined and/or inappropriate drain terminations (i.e. lab drains that terminate at the sanitary sewer).

Facility Y-9207 Biology Complex received one category score of 4, and a total score of 13. In this facility the sinks in a radiological area drain directly to the Oak Ridge sewer system, and thus represent a potential pathway for radiological materials to the city sewage and sludge.

Facility Y-9959 Storage facility received one category score of 4, and a total score of 6. Exterior peeling paint is contributing to environmental contamination. There is minimal chance it will be corrected.

Facility Y-9736 Office building received one category score of 4, and a total score of nine. The exterior paint is no longer in a stable matrix and is contributing to environmental contamination. There is minimal chance it will be corrected.

Facility Y-9959-2 Storage facility received one category score of 4, and a total score of 6. The exterior paint is no longer in a stable matrix and is being spread to the environment.

At **ETTP** twelve facilities had at least one category score of four or five: K-1037-C, K-1004-B, K-1004-A, K-633, K-1025-A, K-1025-B, K-1015, K-1200-S, K-1004-E, K-1004-J, K-1220-N, and K-1401L3.

Facility K-1037-C (Nickel Smelter House) received five category scores of 5, one category score of 4, and a total of 29. This is an old facility in general disrepair. It has numerous roof leaks and is heavily contaminated, both radiologically and chemically. Large scrubber-type vessels located on the East End of the second floor of the barrier production area contain internal radioactive contamination. Discarded contaminated equipment is stored in the building. The facility is posted as a PCB hazard. No corrective actions have been completed at this facility.

Facility K-1004-B (Analytical Chemistry Lab.) received four category scores of 5, and a total of 26. These scores were given for radiological contamination in the ventilation system, and chemical contamination in the drains. No corrective actions have been completed at this facility.

Facility K-1004-A (Analytical Chemistry Lab.) received four category scores of 5, and a total score of 26. These scores were given primarily for chemical contamination in the drain and ventilation systems.

Facility K-633 received five category scores of 5, and two category scores of 4. There is extensive radiological contamination throughout the building, and extensive peeling exterior and interior paint, which contain PCBs, asbestos and lead. External soil contamination suggests radiological material has moved to the environment.

Facility K-1025-A (Radiological Source Control Building) received six category scores of 4, and a total score of 27. The entire building is a contamination zone with plugged floor drains. The building houses radiological sources, and there is evidence that water has been standing in the building. The integrity of the roof is suspect. Floor drains historically went into a French-drain system with an unknown termination point. Elevated radiological readings outside of the building indicate that drains exit into the yard, and that contamination has moved into the environment. No corrective actions have been taken on this facility.

Facility K-1015 received four category scores of 5 and a total of 27. The facility has a contaminated drain system and has contaminated surrounding soils and the sewer system.

Facility K-1025-B (Drum Storage Warehouse) has one category score of 4, two category scores of 5, and a total of 23.5. The primary concern with this facility is radiological contamination. Radiological contamination has moved from within the building via the floor drain system and has contaminated the soil in front of the building. Since a radiological survey map was not available, the magnitude of soil contamination is unknown. The division has not been notified of actions taken to address these issues.

Facility K-1004-E received three category scores of 5 and a total of 21. This facility has a chemically contaminated drain system, and exhibits extensive, peeling exterior lead-based paint.

Facility K-1200-S (Centrifuge Preparation Laboratory, South Bay) received two category scores of 4 and a total score of 26.5. The high score is primarily attributable to the uncertainty of radiological contamination associated with the ventilation system. The interior ductwork and portions of the roof where air is exhausted have not been surveyed for contamination. The potential for airborne release appears great. Equipment inside the facility contains uranium hexafluoride and other hazardous chemicals, and there are numerous radiologically contaminated storage areas. Confined space entry requirements prevented the division from performing a survey of the pits below the centrifuges. The greatest release potential for contaminants would be during decontamination and decommissioning activities. *Equipment removal and cleanup is ongoing at this facility. It is expected that the facility will in the future be removed from the division's "high rankers" list.*

Facility K-1004-J received two category scores of 5, one category score of 4, and a total of 19. This facility was constructed in 1948 and was originally used for uranium recovery from spent fuel solutions and centrifuge research. It originally included a hot cell, reinforced concrete vaults, and a 750 gal. “hot” tank, a 5,500 gal. underground Low Level Liquid Waste tank, and a laboratory. The facility was ranked high in the PER database because of the poor state of knowledge concerning facility infrastructure. First, there is considerable uncertainty over the location and number of active storage vaults under the facility. It is also unknown whether any of these vaults contain radioactive materials or contamination. There is also considerable uncertainty over drainpipe connections and their contribution of radiological and chemical contaminants to general area contamination. No corrective actions have been completed at this facility.

Facility K-1220-N (Centrifuge Plant Demonstration Facility, North) received one category score of 4 and a total score of 18. The interior ductwork has not been surveyed for radiological contamination and the score reflects a high degree of uncertainty concerning the presence of radionuclides. Uranium residuals are present inside the centrifuge systems. After the centrifuge systems are removed and the criticality and security concerns are addressed, this facility is a candidate for reuse. No corrective actions have been conducted at this facility.

Facility K-1401L3 received one category score of 4, and a total score of 15. This ranking was given because of extensive radiological contamination that encompasses the building and housed equipment. There are also suspect contaminated areas that have not been surveyed, such as the areas above 8 feet.

At **ORNL** twenty one facilities had at least one category score of four or five: X-3028, X-3019-B, X-3001, X-7700, X-7700C, X-7701, X-7706, X-7707, X-7720, X-7700B, X-2545, X-3504, X-2531, X-3592, X-3002, X-3020, X-3108, X-3091, X-3085, X-7602, and X-7055.

Facility X-3028 received two category scores of five, five category scores of 4, and a total score of 36. The primary issue with this facility was the relatively large source term of radiological contamination distributed throughout the building. It also shows extensive peeling and chipping of interior wall paint that is supposed to serve as containment for plutonium contamination. Ongoing corrective actions are occurring at this facility.

Facility X-3019-B (High Level Radiation Analytical Laboratory) at ORNL has four category scores of 4, one category score of 5, and a total score of 33. The primary concern with this facility is the very high levels of radiological contamination. The eight hot cells in this facility are “Very High Radiation Areas” and contain many different radionuclides from past operations. The in-cell steam pipes, the off-gas ventilation system, and the ventilation ductwork on the roof are also radiologically contaminated. Also, the Laboratory Off-Gas ductwork located above the hot cells contains perchlorates six times above the maximum recommended by the ORNL Perchloric Acid Committee Corrective. Perchlorates are shock sensitive and have the potential to react violently when disturbed. Signage identifying this hazard is posted, and the situation was recently upgraded from an “Off-normal” to an “Unusual Occurrence.”

Facility X-3001 (Graphite Reactor) at ORNL has two category scores of 4, and a total score of 28. The primary concern with this facility is that there is considerable radiological contamination. The air exhaust shaft that vented the reactor pile is contaminated with cesium-137, strontium-90, and fission products. This is a source releasable to the outside environment if a fire or other event occurred in the ventilation system. Several corrective actions, such as the plugging of drains that went to the sewer system, were recently implemented at this facility.

Facilities X-7700, 7700C, 7701, 7706, 7707, 7720, 7700B (Towers, scrapyard, above-ground storage areas, waste storage tank, reactor pool, heat exchanger bldg., battery house, civil defense bunker, below-ground outside source storage area) are all part of the Tower Shielding Complex. A survey of this group of facilities resulted in two category scores of 5, and 14 category scores of 4. The primary issues at this complex of facilities are: soil contamination, uncovered activated and contaminated equipment and material, and drain lines that have direct connections to the environment. Ongoing corrective actions are being carried out at this facility.

Facility X-2545 (Coal Yard Runoff Collection Basins) at ORNL has one category score of 5, two category scores of 4, and a total score of 21. Orphaned, 2- and 6-inch diameter, cast iron Low Level Liquid Waste (LLLW) lines run through the facility property, and a LLLW line box is posted as a radiation area. The area has been chained off and is overgrown with vegetation. Due to the radiological postings, the cast iron LLLW lines are assumed to be degraded and leaking to the environment. ORNL Environmental Restoration staff has been notified of these lines and their condition, but TDEC has not received written confirmation concerning corrective actions.

Facility X-3504 (Geosciences Lab.) received one category score of 5, one score of 4, and a total of 20. The entire building is a posted contamination area. There is also underground and soil contamination outside of the building.

Facility X-2531 (Radiological Waste Evaporator Facility) received one category score of 5, one score of 4, and a total 21. This ranking includes #2537 (Evaporator Pit) and #2568 (HEPA filter bldg.). Even though this is a relatively clean, modern facility, it earned these scores because of several areas of transferable radiological contamination, and high radiological dose rates surrounding the evaporator pit.

Facility X-3592 (Coal Conversion Facility) received two category scores of 4, and a total of 27. Its original mission was to explore the potential for utilizing liquefied coal as an alternative fuel source. But in later years the facility performed Lithium isotope separation using massive quantities of mercury. The scores were given for transferable radiological contamination and mercury contamination in the drains.

Facility X-3002 (HEPA Filter House for the Graphite Reactor) has one category score of 4, and a total score of 18. The primary hazards associated with this building are related to the high level of airborne and other radiological contamination in the roughing filter room, the HEPA filter bank, and the ventilation system. Several corrective actions that were recommended by the division were implemented at this facility.

Facility X-3020 (Radiological stack for bldg. 3019A-B) received three category scores of 5, and a total score of 18. All of the major concerns noted for this facility were related to legacy features that are not part of the present-day operational infrastructure. There is an antiquated, contaminated drain line that was part of the ORNL LLLW system. This line leaked and contributed to surface and subsurface contamination of the general area from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing contamination. There is also a contaminated, above-grade, single-walled concrete sump box attached to the floor drain system.

Facilities X-3108 and 3091 (HEPA filter houses for buildings 3019A-B and Radiological Stack 3020) each received three category scores of 5. #3108 received a total score of 23, and #3091 received a total score of 25. These two facilities are physically connected to the #3020 stack. And like the 3020 Stack situation described above, all major concerns noted with these facilities are related to their non-operational infrastructure. Associated with both facilities is a contaminated drain system that went to the LLLW system. This line leaked and contributed to general-area surface and subsurface contamination from the 1940's through the 1970's. It was capped in the late 1970's, but is possibly still contributing to contamination. Both facilities also contain significant levels of radiological contamination, considerable contaminated aboveground ductwork, and contaminated lower-level HEPA filter pits. Both facilities are non-state-of-the-art structures that are adequately maintained.

Facility X-3085 (Oak Ridge Research Reactor Pumphouse) received one category score of 4, and a total score of 25. This score was based on the possibility for underground leakage of contaminated water from the 10,000-gallon decay tank, and from the underground valve sump tank located in the front of the building. Two empty but internally contaminated, aboveground tanks are still tied to underground piping adjacent to the building. Several recommended corrective actions, such as the plugging of floor drains, have been completed at this facility.

Facility X-7602 (Integrated Process Development Lab.) received one category score of 4, and a total score of 17. The primary concern with this building was the extensive transferable radiological contamination throughout the facility.

Facility X-7055 (Storage Bldg.) scored one category score of 4, and a total score of 7. The only concern with this building was that it has a floor drain system that is connected directly to the outside yard. Even though the building has changed missions and several corrective actions have been implemented, it still contains hazardous materials.

**Conclusion**

The historic release of chemical and radiological materials from buildings and other facilities on the Department of Energy's Oak Ridge Reservation has led to elevated levels of contaminants in regional terrestrial and aquatic ecosystems. In an effort to understand more about the sources of these contaminants, the division investigates the historic and present-day potential for release of contaminants from facilities through its Facility Survey Program. During its ten-year history the program has examined 172 facilities and found that thirty five percent (61) pose a relatively high potential for release of some contaminant to the environment. In many cases legacy contamination from degraded facility infrastructure, such as underground waste lines, or substandard sumps and tanks, or ventilation ductwork, will force high scores until antiquated facilities are fully remediated. This is particularly the case at Oak Ridge National Laboratory where many facilities were connected to an aging low-level liquid waste line system. Inactive facilities that are no longer receiving adequate exterior or interior maintenance are also driving high scores. On many buildings, peeling lead-based paint is extensive, and will only get worse as time passes, if not remediated. Accelerated infrastructure reduction programs that began at Y-12 and ORNL in 2002 will help mitigate some of these problem areas.

When facility concerns are noted by the division they are relayed to the Department of Energy via the Facility Survey Report so that corrective actions can be formulated. To date, many corrective actions have occurred, and ten facilities have been removed from the division's list of high Potential Environmental Release facilities. Those concerns that have not been corrected to the extent that the division has reduced the Potential Environmental Release score to less than a "4" are reflected in this report. The rankings are changed when written documentation is received by the division from DOE. And, since the evaluation of corrective actions is an ongoing, time-consuming process, present scores may in some cases not reflect the most recent completed corrective actions.

**References**

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. 1994-03. Facility Survey Files.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

U.S. Department of Energy. *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences.* 1997. U.S. Department of Energy, Office of Environmental Management. Oak Ridge, Tennessee.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Follow-up on Environmental Restoration Maintenance Reduction Actions on the Oak Ridge Reservation

Principal Author: Robert Storms


**Abstract**

The Oak Ridge Reservation (ORR) was placed on the National Priorities List (NPL) in 1989. The purpose of Footprint Reduction was to identify portions of the ORR that have not been environmentally impacted by past federal (Department of Energy – DOE) activities. The mission was to determine which land parcels could be conditionally released from Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements. CERCLA 120-(h) was used as the guideline by the footprint team for the footprint investigations.

The goal was further identified as reducing the size and configuration of the area of the ORR designated as part of the NPL site and determining a No Further Investigation (NFI) status. The land parcels were assigned numerical identifiers ranging from 1 through 20. The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and exit pathway releases on the ORR, which could render the parcel(s) unfit for release. In summation, the division investigated 21,439 acres of ORR land during the footprint project. In performance of the field investigation work, certain maintenance action items were identified on the various land parcels, i.e., "study areas" (see Appendix I). The division clearly emphasized these concerns to DOE in each footprint study area report released to the public. This current project revisited these sites to determine if action had in fact been taken by DOE to rectify the problems and other division concerns.


**Introduction and Scope**

The ORR was placed on the National Priorities List (NPL) in December 1989, as a high priority hazardous waste site requiring remediation. In 1992, the Department of Energy (DOE), the U. S. Environmental Protection Agency, and the division negotiated the Federal Facility Agreement (FFA) for environmental restoration activities on the ORR. DOE is responsible for cleaning up the ORR following the CERCLA process, which assesses the impacts of ORR areas on human health and the environment. To fulfill this requirement, potential contamination information was collected and reviewed to determine whether CERCLA response activities were needed followed by in the field investigation of ORR areas.

A proposal was submitted to the division in March 1996 outlining a process designed to identify portions of the ORR that have been environmentally affected by past federal activities. The DOE Environmental Restoration Footprint Reduction process was designed to investigate and assess those areas of the ORR likely to have been environmentally affected by past federal activities. In addition, determinations were made as to which land parcels could be conditionally released from CERCLA requirements and removed from NPL status. The focal regulatory requirement for the project was the CERCLA 120-(h) investigative process, which is used to identify the presence or likely presence of hazardous substances on property being transferred by federal agencies. The

CERCLA 120-(h) investigative process use the following information sources to identify the presence of hazardous substance contamination on federal land: historical land use information, aerial photography, remote sensing data including gamma aerial reconnaissance photos, and field investigation/verification.

The division performed a radiological walkover and reconnaissance survey of each parcel and adjacent land. The investigation focused on identifying potential anthropogenic sources of contamination and resulting release pathways on the ORR, which might render the parcel(s) unfit for release. The contamination could be in the form of solid waste, radiological waste, hazardous waste, or in surface water. Groundwater contamination will be addressed in detail if the property is released to the public.

Areas or facilities found to be contaminated within the various study areas during the parcel evaluation were added to Appendix C of the Federal Facility Agreement (FFA) as CERCLA maintenance action sites. Uncontaminated study areas or portions of study were recommended for No Further Investigation status under the Footprint Reduction program.

The goal of the program was to reduce the size and configuration of the "footprint" area acerage of the ORR ("behind the fence") designated as part of the NPL site. Essentially, the effort was designed to distinguish "greenfield" from "brownfield" areas behind DOE institutional control boundaries.

During the execution of the fieldwork on each footprint study area, certain maintenance action items were determined in need of removal. Additional areas were found where abandoned field gear and trash from research projects needs clearing or removal. Each footprint parcel was investigated and a final report on the respective study area was generated and issued by the footprint team. The division clearly identified maintenance action problem areas to be addressed by DOE in each of the applicable 20 footprint study area reports (not all parcels had cleanup problems). During calendar year 2003, the division "follow-up footprint project" revisited all the previously determined maintenance action sites to determine compliance with the requested maintenance actions.

In addition, the division has added the parcel ED-1 Mitigation Action Plan (MAP) requirements into this project as well. Required environmental monitoring by DOE and CROET per the MAP has become a concern. The division will follow-up on this project with field excursions in addition to requesting DOE to honor its responsibilities per the MAP document.

**Methods and Materials**

The purpose of Footprint Reduction was to identify portions of the ORR potentially impacted by past federal activities. The division performed a radiological walkover and reconnaissance survey of twenty parcels and adjoining land. The field investigation focused on possible anthropogenic sources of contamination that might render each parcel unfit for release. The parcels were investigated and walked over by division staff using field radiological detection instruments (i.e., Ludlum model 2221 scaler ratemeter with a 2 x 2 inch sodium iodide crystal). A portable gamma spectrometer equipment was used to identify isotopes present at sites where above background detections of radiation were discovered. The division also used a micro-rem meter that provides data in tissue dose equivalent units (rem). Global positioning system (GPS) technology was employed to locate field survey points and to confirm the location of anomalous features.

Historical land use investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic and radiologic anomalies were plotted on maps prepared by the then Lockheed Martin Energy Research (LMER) Geographic Information Science and Technology (GIST) staff for field investigation applications. The division reviewed the map and other data furnished by LMER GIST staff, as well as all pertinent information and data from division files. The magnitude, sheer size of the area to survey, and topography of the land parcels precluded the use of grid survey techniques. After a detailed study of survey techniques and requirements, it was determined that the survey effort would concentrate on mapped locations of magnetic and gamma fly-over anomalies. Aerial photography was investigated and studied thoroughly to evaluate potential land use changes over time.

The division investigated the anomalies identified on the anomalies maps plus suspicious sites observed on historical aerial photos. Cultural changes, non-sequential vegetation changes, radiological anomalies, and geophysical anomalies were investigated. Karst features, springs, abandoned and existing roads, and other unusual sites were inspected when found in the field. Threatened and endangered plant species and Native American sites were on the list of potentially important sites to be considered for exclusion and protective status.

The physically demanding and time-consuming task of walking over the parcels provided the best method of coverage and obtaining the best quality and most reliable information. Routes were selected that would ensure maximum coverage of the parcels. Abandoned roads and trails were walked to determine if hazardous materials or wastes had been dumped on site. Magnetic anomalies were examined to ensure that there were no observable metals, wastes or structures present. Remote areas were investigated to determine if evidence of past federal activities were present. Division staff concluded fieldwork on all of the 20 parcels in early 2000 (totaling approximately 24,754 acres. (See Figure 2)

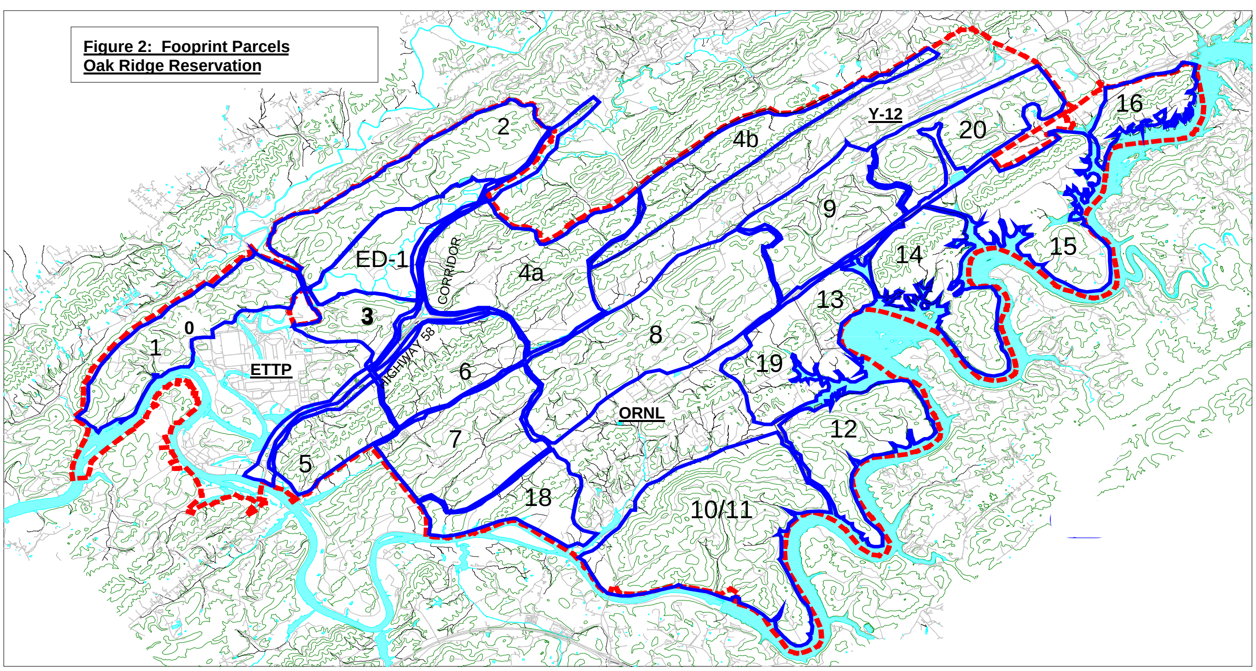


**FIGURE 2: Footprint Parcels – Oak Ridge Reservation**

## Results and Discussion

Division field teams located the pre-mapped anomalies in the field utilizing GPS technology. Measurements of ambient gamma radiation were taken at each anomalous site or survey site to determine if any contamination from DOE operations (or its federal predecessors) could be detected. Other points were selected and investigated on a random or functional as-needed basis.

Historical investigations, aerial photography analysis, and remote sensing data were studied for evidence of federal activities that could have potentially resulted in adverse impacts to the environment. Magnetic, historical and radiological anomalies were plotted on maps to assist the field investigation team.

During the course of the five (5) plus year Footprint Reduction project, several maintenance action sites in need of remediation were identified. In addition, several new solid waste management units (SWMUs) were discovered and recommended for exclusion from the parcels. (See Figure 1 for locations of all sites) All these sites were to be addressed by DOE at a later date (See Appendix 1 for the maintenance action list). The SWMU sites were given priority by DOE and it's subcontractors for appropriate maintenance action. Identification numbers and names were assigned to the sites, and each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated), placarded, or otherwise flagged, and was added to the FFA Appendix C list. There was one small barn structure at ETTP that was found to have fixed contamination (radiological) on its floor. This facility was immediately provided with appropriate institutional controls as a radiological area.

The intent of this current "follow-up" project was to revisit those areas of concern and determine the status of the requested maintenance actions. All sites were compared to the Appendix C of the FFA to ensure inclusion. Unfortunately, due to budgetary cut-backs or prioritization changes on DOE's part, none of the maintenance action sites except for the SWMUs have received the requested attention or response.

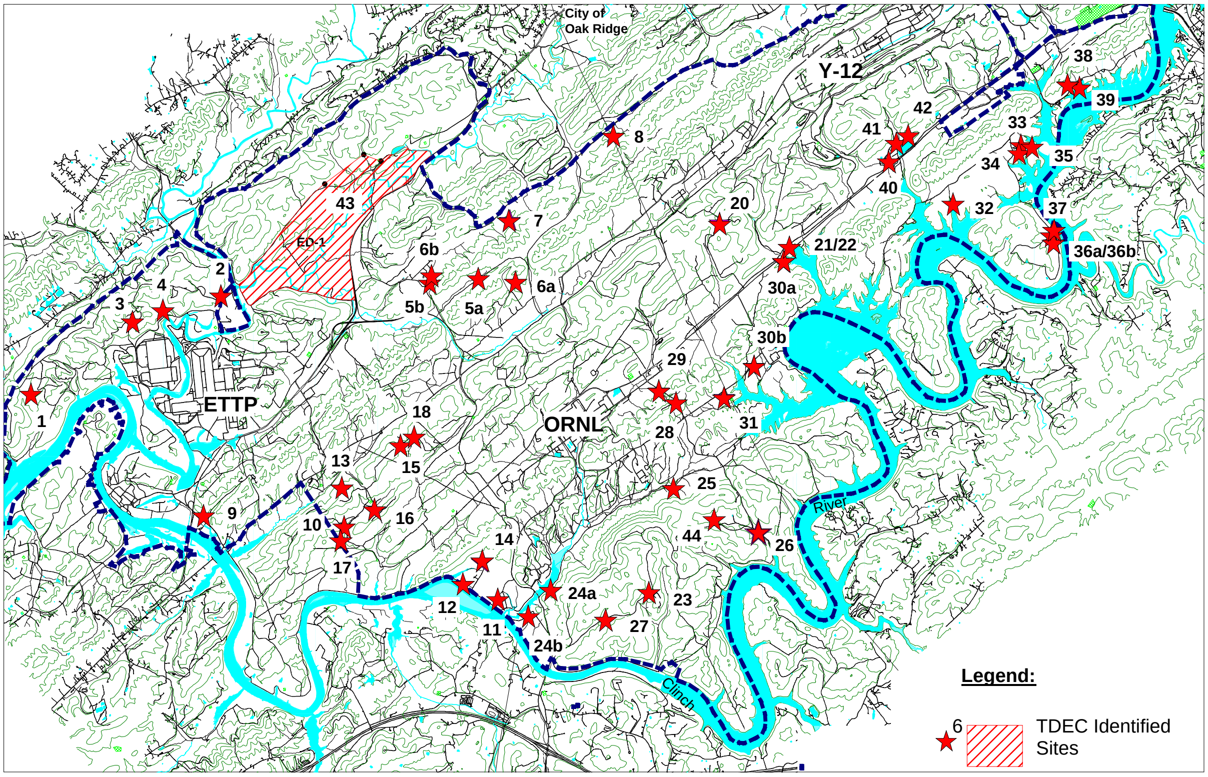


**FIGURE 1: Footprint Reduction – Maintenance Action Sites**

## Conclusions

During 2003, division staff returned to the location of the 44 sites listed in Appendix I to investigate and determine if requested maintenance actions from the division had been carried out by DOE to alleviate the problems. Essentially, no action has been taken to address the sites of concern. Therefore, concerns by the division continue to be justified for (public) human health and the environment due to DOE's lack of response. DOE appropriately addressed the new SWMU sites discovered by the division. Each SWMU was cordoned off with yellow and magenta rope (if radiologically contaminated), placarded, or otherwise flagged, and was added to the FFA Appendix C list.

Division staff will continue to vigorously follow-up on the areas of concern until the desired response by DOE is achieved thereby providing resolution of concerns by the division. The possibility that groundwater contamination will migrate from impacted areas of the ORR into the study areas exists and constitutes the need for groundwater use restrictions.

## References


Site and Facilities Planning, et al., *Evaluation of Copper Ridge Study Area.* DOE/OR/01-1697&D1, July 1998. Bechtel Jacobs Company, LLC, Oak Ridge, Tennessee.

Site and Facilities Planning, et al., *Evaluation of West Black Oak Ridge Study Area.* DOE/OR/01-1590&D1, September 1997. Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, July 1999. *Environmental Restoration Footprint Reduction Process – Evaluation of the Freels Bend Study Area.*

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, October 1999. *Environmental Restoration Footprint Reduction Process – Evaluation of the East Chestnut Ridge Parcel.*

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. 2002. *TDEC DOE-Oversight Division Environmental Monitoring Report – January through December 2002.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. 2002. *TDEC DOE-Oversight Environmental Monitoring Plan – January through December 2002.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 1992. *Federal Facility Agreement for the Oak Ridge Reservation.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

U. S. Department of Energy. Annual Report – *Implementation of Mitigation Action Plan for DOE/EA-1113: Lease of Parcel ED-1 of the Oak Ridge Reservation, Pre-Development Ecological Surveys*. DOE/EA-1113/MAP-97. November 1997. Oak Ridge Operations, Oak Ridge, Tennessee.

U. S. Department of Energy. Annual Report – *Implementation of Mitigation Action Plan for DOE/EA-1113: Lease – Parcel ED-1 of the Oak Ridge Reservation.* DOE/EA-1113/MAP-98. December 1998. Oak Ridge Operations. Oak Ridge, Tennessee.

U. S. Department of Energy. *Environmental Assessment – Lease of Parcel ED-1 of the Oak Ridge Reservation by the East Tennessee Economic Council*. April 1996. DOE/EA-1113. Oak Ridge Operations. Oak Ridge, Tennessee.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

## APPENDIX I

### LIST OF MAINTENANCE ACTION SITES IDENTIFIED BY TDEC FIELD SURVEYS (FOOTPRINT REDUCTION PROCESS)

| Map Reference | Maintenance Action Concern and Site Description |
|---|---|
| | |
| | **Parcel 1: West Black Oak Ridge Study Area** |
| 1 | TDEC field station 101: Abandoned 55-gallon steel drum (empty) |
| 2 | TDEC field station 127: Old dumpsite (tires, roofing, scrap metal, etc.) |
| 3 | TDEC field station 129: Small shed with above background levels of fixed gamma contamination |
| 4 | TDEC field station 134: Large abandoned hollow fill |
| | |
| | **Parcel 2: East Black Oak Ridge Study Area** |
| | None specified |
| | |
| | **Parcel 3: McKinney Ridge Study Area** |
| | None specified |
| | |
| | **Parcel 4a: East Fork Ridge/White Wing Study Area** |
| 5a/5b | TDEC field stations 24 & 125: Abandoned 55-gallon drums |
| 6a/6b | TDEC field stations 105-124: Numerous abandoned hydrologic experimental equipment |
| 7 | TDEC field station 157: Remains of plywood shack and drums |
| | |
| | **Parcel 4b: Pine Ridge Study Area** |
| 8 | TDEC field station 89: Abandoned barrel with residual fuel oil |
| | |
| | **Parcels 5/6: West Pine Ridge Study Area** |
| 9 | TDEC field station 44: Old Dump Site at west end of Happy Valley Campsite |
| | [Radiological surveys should be conducted prior to use of federal land adjacent to the Consolidated Clinch River Industrial Park to ensure potential exposure is minimized] |
| | |
| | **Parcels 7/18: West Chestnut Ridge/West Bethel Valley Study Area** |
| 10 | TDEC field station 14: Abandoned 55-gallon drum |
| 11 | TDEC field station 26: Pile of scrap metal |
| 12 | TDEC field station 35: Abandoned automatic sampling equipment along small creek |
| 13 | TDEC field station 49: Experimental hydrologic site with abandoned equipment & test gear |
| 14 | TDEC field station 89: Abandoned hydrologic/precipitation experimental equipment |
| 15 | TDEC field station 103: Abandoned soil percolation test trenches and test gear |
| 16 | TDEC field station 105: Abandoned hydrologic experimental gear strewn about the hillside |
| 17 | TDEC field station 114: Abandoned experimental site and test gear |
| 18 | TDEC field station 193: Abandoned percolation test trench and equipment |

| Map Reference | Maintenance Action Concern and Site Description |
|---|---|
| | |
| 19a/19b | TDEC field stations 250/251: Abandoned hydrologic test site with copious amounts of abandoned equipment |
| | |
| | **Parcel 8: Central Chestnut Ridge Study Area** |
| 20 | TDEC field station 15: Debris & scrap metal strewn about the NOAA/ATDD facility |
| 21 | TDEC field station 168: SWMU 0.81 site including broken asphalt, concrete, scrap metal, & local dumping of trash; [same location as map reference 22] |
| | |
| | **Parcel 9: Walker Branch Study Area** |
| 22 | TDEC field station 77: Removal action requested for miscellaneous trash and debris associated with SWMU 0.81<br>located between Old and New Bethel Valley Roads [same location as map reference 21] |
| | [Removal action is recommended for abandoned experimental gear, scrap metal, hydrologic test equipment and trash strewn about the entire parcel] |
| | |
| | **Parcel 11: Copper Ridge Study Area** |
| 23 | TDEC field station 27: General vicinity of the Civil Defense Bunker needs trash picked up |
| 24a/24b | TDEC field stations 119 & 297: Abandoned drums |
| 25 | TDEC field station 133: Gamma-contaminated site along old roadbed on ridge overlooking HFIR to the north |
| 26 | TDEC field station 250: Abandoned & unidentified waste dump (scrap metal, blocks, bricks, etc.) |
| 27 | TDEC field station 313: Tire dump |
| 44 | "Cesium Forest" |
| | |
| | **Parcel 12: Park City Road Study Area** |
| | None specified |
| | |
| | **Parcel 13/19: West Haw Ridge/Bearden Creek Watershed Study Area** |
| 28 | TDEC field station 12: Previously unidentified SWMU contaminated with Cs-137 |
| 29 | TDEC field station 21: Small dump site adjacent to Melton Valley Access Road which is slightly rad-contaminated |
| 30a/30b | TDEC field stations 50 & 139: Abandoned empty 55-gallon drums |
| 31 | TDEC field station 89: Previously SWMU dump (lab equipment, scrap metal, etc) |
| | |
| | **Parcel 14: Gallaher Bend/Bull Bluff Study Area** |
| | None specified |
| | |
| | **Parcel 15: Freels Bend Study Area** |
| 32 | TDEC field station 6: Abandoned 55-gallon drum partially submerged in a cove along the shoreline of Melton Lake |
| 33 | TDEC field station 20: VDRIF facility needs to have shielding blocks removed from the roof of the structure |
| 34 | TDEC field station 21: Demolition debris needs cleared and removed |
| 35 | TDEC field station 23: Location of small subterranean vault which held lead source rods; reportedly sand filled |

| Map Reference | Maintenance Action Concern and Site Description |
|---|---|
| | |
| 36a/36b | TDEC field stations 35 & 36: Existing barns need to be cleared of trash & veterinary IV needles/medicine bottles |
| 37 | TDEC field station 52: Trash and debris disposed in large sinkhole (standing water) |
| | |
| | **Parcel 16: Scarboro/East Haw Ridge Study Area** |
| 38 | TDEC field station 6: Anomaly 12 at contaminated trailer |
| 39 | TDEC field station 7: Building 1404-7 at the location of a radiologically-contaminated hopper |
| | |
| | **Parcel 20: East Chestnut Ridge Study Area** |
| 40 | TDEC field station 36: Abandoned scrap pile/refuse along the Brush Burn Access Road |
| 41 | TDEC field station 38: Abandoned scrap metal/asbestos pile located north of Rogers Quarry |
| 42 | TDEC field station 39: Abandoned scrap metal pile located north of the Rogers Quarry highwall |
| 43 | Parcel "ED-1" |

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Pilot Project for Radon Monitoring (RMO)

Principal Authors: James Dunlap, Howard Crabtree

**Abstract**

In 2003, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division continued a pilot study designed to assess the feasibility of monitoring radon at burial grounds on DOE's Oak Ridge Reservation. The project was prompted by a concern that the disposal of large amounts of uranium in reservation burial grounds may have resulted in elevated radon levels (radon is produced by the natural decay of radionuclides in the uranium decay series). The results from the initial study in 2001 indicated radon levels could be measured using the technique developed for the project, but the loss of some of the detectors and damage to others by insects or small animals introduced uncertainties that limited the use of the data. It was subsequently decided to continue the study, but deploy the detectors during the winter/spring months in an effort to avoid some of the problems encountered in 2001. In February 2003, the second set of detectors was placed over the burial grounds in Bear Creek Valley, left in place for four months, then retrieved and analyzed. While the results for 2003 were much lower than those in 2001, data from both efforts indicated that radon can be measured using the techniques developed for the project and that the radioactive gas was higher over localized areas than the background measurements.

**Introduction**

Radon is a colorless, odorless gas formed by the normal radioactive decay of radionuclides in the uranium decay chain. As radon decays, alpha radiation is released and daughter radionuclides are produced (e.g., polonium-218, polonium-214, bismuth-214, and lead-214). The radon daughters emit the more significant contribution to the total radiation dose associated with radon exposures. Since radon is a gas and the daughters (metals) tend to attach to air-borne particles, exposures present an inhalation hazard, which is believed to be the major cause of lung cancer in the United States today.

Over the years, greater than 40,000,000 pounds of uranium has been disposed in shallow unlined trenches on the Oak Ridge Reservation (ORR), raising a concern that radon and its daughters could be present at hazardous levels. To evaluate the hazards of radon on the reservation, the Tennessee Department of Environment and Conservation Department of Energy Oversight Division initiated a pilot study in 2001 designed to assess the feasibility of monitoring radon levels at waste disposal sites. For this study, radon detectors were placed at background locations and over uncapped portions of the Bear Creek Burial Grounds near the Y-12 National Security Complex (See Figure 1).

The results from the 2001 study indicated the radon concentrations could be measured and suggested the burial grounds have areas where the radon levels are above background concentrations. However, various problems were encountered during the effort. Several of the detectors were damaged (presumably by insects or small mammals), three detectors were lost or displaced by mowers, and uranium wastes were discovered on the ground surface at one of the locations being monitored. In 2003, it was decided to continue the study, but deploy the detectors during the winter/spring months, in an effort to avoid some of the problems encountered in 2001. The second set of detectors were placed over the burial grounds in February 2003 and collected in June 2003.

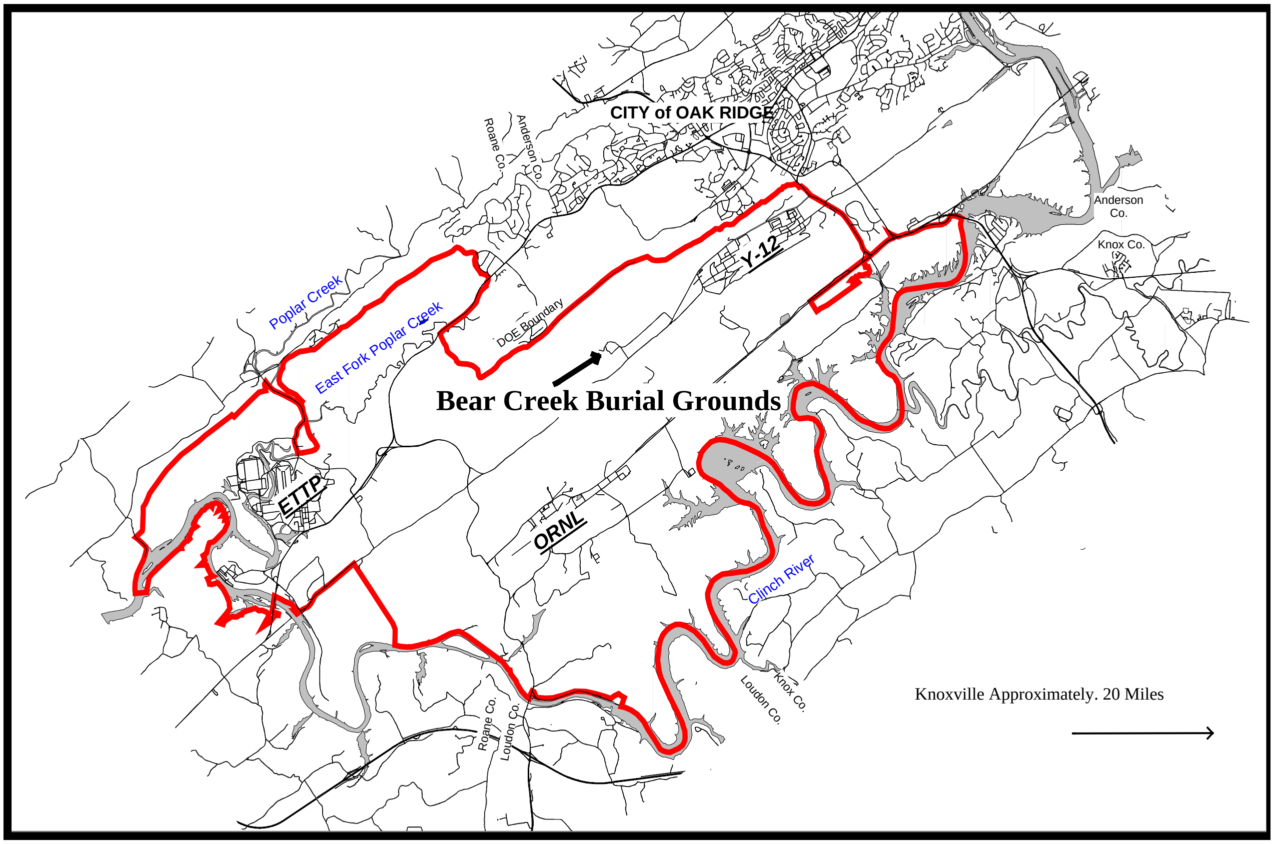


**Figure 1: Bear Creek Burial Grounds**

## Methods and Materials

On February 4, 2003, Radtrak® Radon Gas Detectors were placed at twenty locations spread across uncapped portions of the Bear Creek Burial Grounds. Three additional detectors were placed at background locations in the same geologic formation as the burial grounds. After four months in the field, the detectors were retrieved and shipped to the vendor for processing. The results from the burial grounds were then compared to the background data to determine if radon levels above background concentrations could be identified.

Based on recommendations from the vendor, the detectors were protected from the elements by a housing constructed from five-gallon plastic buckets. Each detector was affixed to the inside surface of the bottom of one of these buckets, then the bucket placed inverted at the monitoring stations and secured with tent stakes. Ventilation for the detectors was provided by holes (one-half inch in diameter) drilled approximately one-inch above the bottom of the buckets. Figure 2 provides the general configuration of the housing.

It should be understood, the sampling methodology used in this program was designed to capture radon emissions released from soils beneath the five-gallon containers: therefore, the measurements are not representative of ambient air concentrations, which should be much less because of natural dispersion mechanisms (e.g., wind) and the dilution provided by the ambient environment.

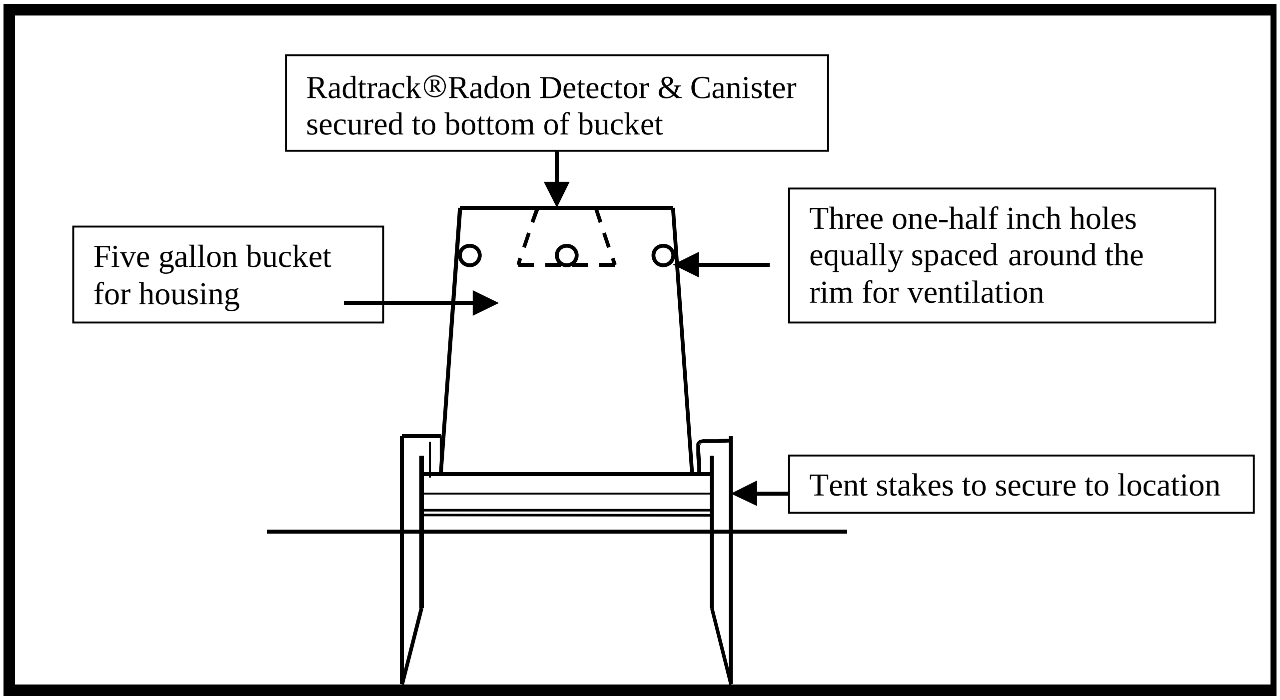


**Figure 2: Configuration of Radon Detector Housing (*not to scale*).**

**Results and Discussion**

In general, ambient radiation levels follow seasonal trends, due to the influence of natural phenomena that control the concentrations of radiation in the environment. In regard to radon, wind movement, precipitation, barometric pressure, and temperature each play a role in these variations and relatively large seasonal fluctuations are considered normal. This affect can be noted in the results for the radon samples taken in 2003, when compared to the data collected in 2001 (See Table 1). In 2001, the samples were collected during the summer months, when radon levels are expected to be at their highest. The 2003 samples were collected during the spring, when radon levels are typically much lower; particularly, where high levels of precipitation are experienced, as was the case in the in 2003. An order of magnitude decrease in the average and median values for the background samples in 2003 indicates the major influence on the results can be attributed to natural seasonal variations that control the amount of radon released through the soils into the atmosphere.

**Table 1: Summary of Results for Radon Samples taken at the Bear Creek Burial Grounds in the Summer 2001 and Spring 2003 (pCi/L)**

| Location/Year | Season | Range | Average | Median |
|---|---|---|---|---|
| Background 2001 | Summer | 3.8-13.8 | 9.5 | 11.0 |
| Background 2003 | Spring | 0.4 - 2.1 | 1.2 | 1.1 |
| Bear Creek Burial Ground 2001 | Summer | 2.8-57.6 | 15.0 | 11.0 |
| Bear Creek Burial Ground 2003 | Spring | 0.6 - 4.5 | 1.6 | 1.25 |

In addition to the above, one of the burial grounds being monitored had been covered by a layer of soil after the 2001 sampling effort, potentially contributing to the lower results reported in 2003. The soil cover had been emplaced to control the spread of uranium wastes discovered on the ground surface by staff deploying the radon detectors during the initial effort. The wastes (See Figure 2), which were believed to be artifacts of a uranium fire, included uranium oxides condensed on rock surfaces, ash, and machine turnings.

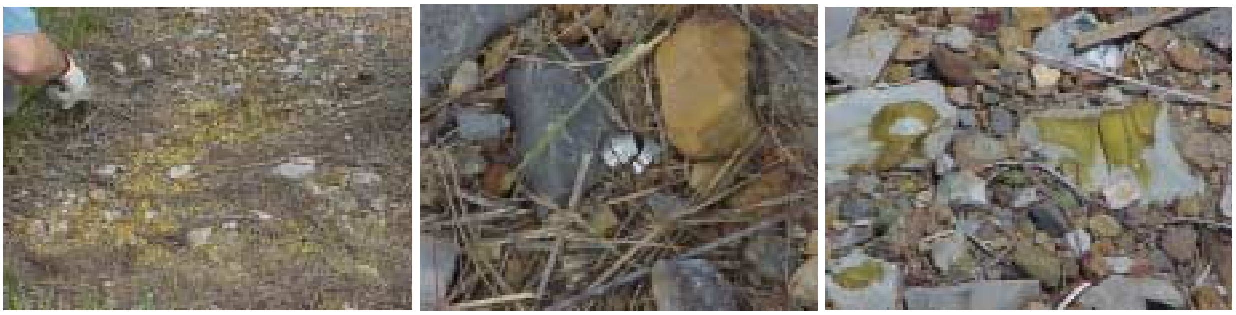

**Figure 2: Radioactive Materials observed in the BG-D East Section of the Bear Creek Burial Grounds *(Photos provided by the Department of Energy)***

Despite the difference in concentrations, there were notable similarities in the results contained in the two data sets: (1) both data sets indicated radon above the burial grounds could be measured; (2) localized areas within the burial grounds exhibited higher radon levels than the background results; (3) the median values for the background locations and the burial grounds were relatively close; and (4) the average concentration for the results from the burial ground measurements was skewed higher than the average for the background measurement by one or two results. Overall, the results collected during the summer 2001 and spring 2003 indicate radon levels over the burial grounds can be measured using the technique developed for the project and localized areas within the burial grounds had radon levels above background concentrations.

**Conclusion**

Results collected during the summer 2001 indicated radon levels over burial grounds on the Oak Ridge Reservation could be measured and suggested localized areas within the Bear Creek Burial Grounds had radon levels above background concentrations. Data from 2003 supported the 2001 findings; but the concentrations measured were roughly an order of magnitude lower than those reported for 2001. The lower measurements in 2003 are believed to be due to routine seasonal fluctuations, enhanced by the relatively high amount of precipitation received during the sampling period.

References

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

U.S. Environmental Protection Agency, 1992 (revised). *Indoor Radon and Radon Decay Product Measurement Device Protocols.* Office of Air and Radiation (6604J) EPA 402-R-92-004.

Yard, C.R., 2002. *Health, Safety, and Security Plan*. Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 5 RADIOLOGICAL MONITORING

## Surplus Material Verification

Principle Author: John McCall

**Abstract**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division's (the division) Radiological Monitoring and Oversight Program conducted random radiological monitoring of surplus material offered for sale to the public. A total of 18 inspection visits were conducted at the three Oak Ridge Reservation (ORR) facilities. The surveys resulted in the discovery of radiological contamination levels above release limits on one item.

**Introduction**

The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division), in cooperation with the U.S. Department of Energy and its contractors, conducts random radiological surveys of surplus materials that are destined for sale to the public on the Oak Ridge Reservation (ORR). In addition to performing the surveys, the division reviews the procedures used for release of materials under DOE radiological regulations. Some materials, such as scrap metal, may be sold to the public under annual sales contracts, whereas other materials are staged at various sites around the ORR awaiting public auction/sale. The division as part of its larger radiological monitoring role on the reservation conducts these surveys to help ensure that no potentially contaminated materials reached the public. In the event that radiological activity is detected, the division immediately reports the finding to the responsible supervisory personnel of the surplus sales program and follows their response to the notification to see that appropriate steps (removal of items from sale, resurveys, etc.) are taken to protect the public.

**Methods and Materials**

Staff members make random surveys of items that are arranged in sales lots by using standard survey instruments. Inspections are scheduled just prior to sales after the material has been staged. Items range from furniture and equipment (shop, laboratory and computer) to vehicles and construction materials. Particular attention is paid to items originating from shops and laboratories. Where "green tags" are attached, radiation clearance information is compared to procedural requirements. If any contamination is detected during the on-site survey, the surplus materials manager for the facility is notified immediately.

**Results and Discussion**

A total of 18 inspections were conducted at the three facilities (ORNL, Y-12 and ETTP). The majority of those were at Y-12 and ORNL surplus sales prior to public auctions. The division had one significant finding from these inspections. A division radiological survey conducted at ORNL Surplus Sales during November 2003 revealed radiological contamination on a large impact wrench. After a re-survey by ORNL RCTs, the wrench was enclosed in bags to isolate the contamination and a radiological tag was applied to the wrench. Later the wrench was removed from the site to be disposed of as contaminated waste.

**References**


Tennessee Department of Environment and Conservation. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Environmental Monitoring Plan.* 2003. Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Yard, C.R. 2002. *Heath, Safety, and Security Plan,* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division, Oak Ridge, Tennessee.

# CHAPTER 6 SURFACE WATER MONITORING

## Monitoring of Uranium Transport in Bear Creek

Principle Author: John Edward Sebastian: RRPT, PG

**Abstract**

In 2003, the Bear Creek Uranium Study built upon and is a continuation of the 2001 and 2002 Bear Creek Uranium Studies. In 2001, it was observed that uranium in Bear Creek Valley was delivered into Bear Creek and its associated karst and fracture flow groundwater systems along a few discrete, high-concentration, low-flow surface and subsurface drainages. After the initial migration of uranium into the creek, the contaminant followed a complex interconnected surface and subsurface pathway. In 2002, ambient rainfall controlled the fate and transport through the complex fracture and conduit groundwater flow system (as well as the surface systems) to and through Bear Creek. In 2003, the data suggests that surface waters were the dominate pathway for the transport of uranium from the disposal sites through Bear Creek Valley and anthropomorphic activities may have resulted in a significant increase in the flux of dissolved uranium.

**Introduction**

Uranium dissolved in the waters of Bear Creek on the Department of Energy (DOE) Oak Ridge Reservation originates in the western portion of the Y-12 Plant and numerous disposal sites located in Bear Creek Valley. Over the last three years, the Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) has collected radiological samples and flow measurements along this creek, its tributaries, and associated springs in an attempt to determine the source, transport, and fate of the uranium. As uranium is an emitter of alpha radiation, the project used gross alpha measurements as indicators of the uranium concentrations in the waters sampled. Using these measurements and the estimated flow of each stream at the time of sampling, the flux of alpha moving past the sampling point was calculated. These fluxes were then used to estimate the sources, transport, and fate of uranium in Bear Creek and its associated groundwaters.

*Location:* Bear Creek Valley is located on the Oak Ridge Reservation within East Tennessee’s Valley and Ridge Physiographic Province. The valley lies between Pine Ridge (to the map north) and Chestnut Ridge (to the map south) and trends in a general northeasterly and southwesterly direction that is common to the long narrow valleys of this physiographic province. Bear Creek, along with its integral complex karst and fracture flow groundwater systems, drains the western portion of the Y-12 complex and a number of sites used to dispose of depleted uranium and other wastes from past DOE processes.

*Geology:* Fractured clastic and carbonate Cambrian aged sedimentary rocks of the Conasauga Group underlie Bear Creek Valley. Sedimentary beds strike in a general northeastern manner and dip approximately 30 to 45 degrees toward the southeast. Within the regional structure of imbricate thrust blocks (Bear Creek Valley and its bordering ridges form part of one such block), deformation can become too complex for description. The valley is segregated into a number of fractured clastic formations that underlie the majority of the valley’s surface and one well developed karst unit, the Maynardville Limestone, which runs parallel to the base of Chestnut Ridge and in some areas forms the lower slopes of Chestnut Ridge. Adjacent to the Maynardville

Limestones are the dolomites of the Cambrian and Ordovician aged Knox Group formations. The Knox Group aquifer is also a developed karst dominated by conduit flow groundwaters.

*Hydrogeology:* Groundwater and surface water movement in the valley is dominated by the well-developed karst of the Maynardville Formation. With the exception of occasional deeper fracture systems within the clastics, much of the meteoric water that falls on the clastic units is carried by surface or near surface runoff into Bear Creek and its underlying karst aquifer. The creek itself is merely the surface expression of the well-developed karst drainage and is composed of a series of gaining and losing stretches. In at least one location, the creek as a whole can be observed seasonally cascading into a swallet formed in the limestone of the creek bed. In this regard, the upper reaches only flow continuously when the underlying karst has been filled to capacity with rainwater. A series of springs, which most likely represent a seasonally variable mixture of waters from the Maynardville karst aquifer and the adjacent Knox Group aquifer, exist along the base of Chestnut Ridge and contribute considerably to the flow of the Bear Creek System.

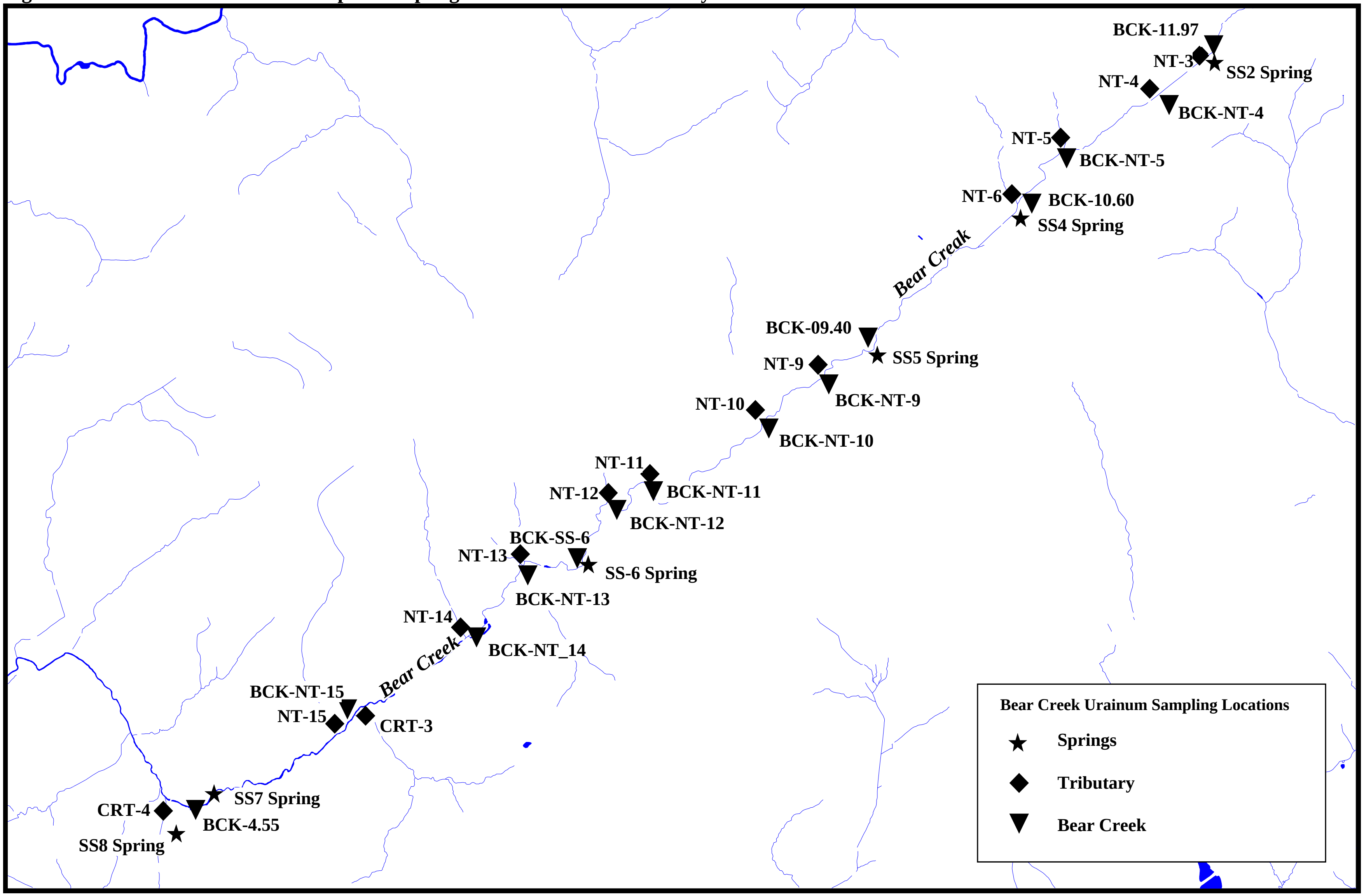
**Method and Materials**

The sampling points in the project (See Figure 1) can be divided into three groups: springs, tributaries of Bear Creek and Bear Creek itself. Each of the sampling points in the three groups is related to the others in such a way that a cross section of the watershed could be sampled essentially simultaneously. Quarterly gross alpha concentrations (pCi/L) and flow measurements (L/s) were used to calculate the flux of alpha moving through system (i.e., pCi/L*L/s = pCi/s). The locations and timing of the sampling was chosen to provide a determination of both the source and fate of the contaminant mass.

For the purposes of the study, gross alpha concentrations were assumed to be representative of dissolved phase uranium (an alpha particle emitter) in the waters of Bear Creek Valley. To verify the accuracy of this assumption, alpha spectography was performed on a series of samples and the results compared to gross alpha concentrations measured for the same sample. This comparison indicated the gross alpha measurements could provide a reasonable estimate of the uranium moving through the hydrological system.

Flow measurements at each location were derived by the best available means. Where weirs had been emplaced, they were used to calculate the flow. At other locations, the flow had to be estimated. While these estimates have a high degree uncertainty, even very large margins of error (50% or greater) would not be expected to alter associated conclusions significantly. In this regard, a review of flow measurements taken by the U.S. Geologic Survey along Bear Creek indicate that there are no measurements in this study that are unusual or unlikely for Bear Creek or its environs. Further, the data gathered are logical from one sampling point to another and consistent with other studies performed in the same area. Nevertheless, the uncertainty associated with the flow measurements is considered problematic, along with the lack of a more accurate method to gauge the movement of sediments.

Figure 1: 2003 Uranium and Gross Alpha Sampling Points in Bear Creek Valley



## Results and Discussion

*Bear Creek:* In 2002 results from Bear Creek showed not only an expected downstream diminution of gross alpha concentrations, but also an unexpected decrease in the flux of gross alpha. 2003 results showed a markedly different behavior. During 2003, the gross alpha flux was seen to have diminished in the upper reaches of the creek and to have increased in the lower reaches of the creek. Figures 1 and 2 show the gross alpha flux at Bear Creek Kilometer (BCK) 11.97 in 2002 and 2003, respectively. BCK 11.97 is located just below the confluence of North Tributary (NT)-3, which has historically been a major contributor of uranium to the waters of Bear Creek Valley. As can be seen in the figures, the flux during 2003 was remarkably reduced.

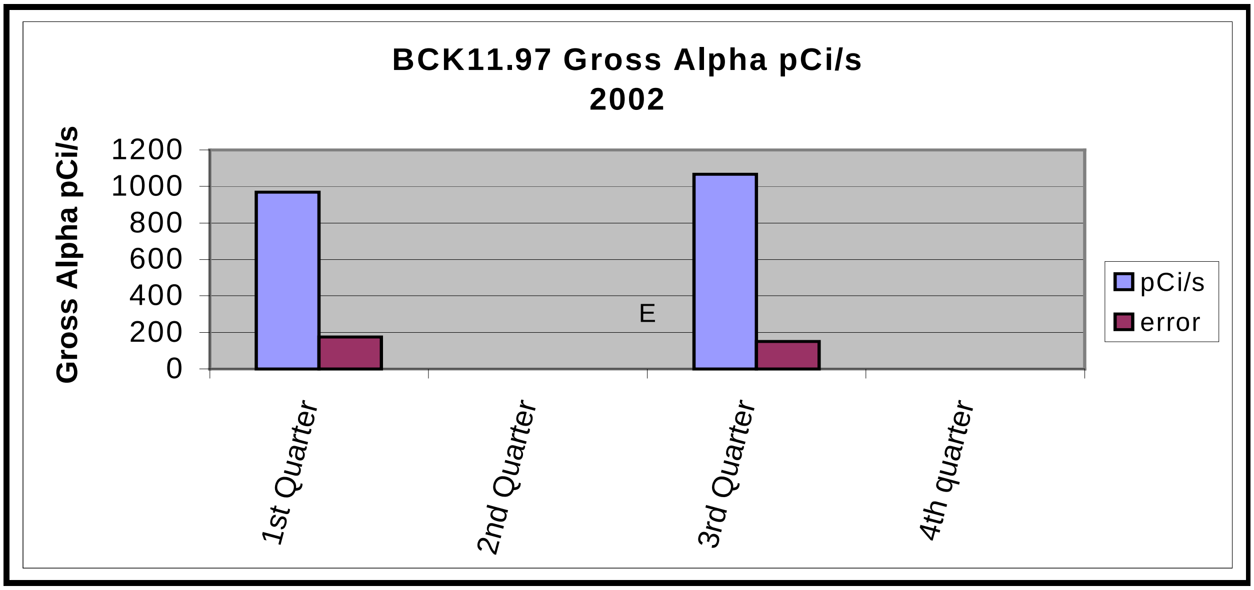



**Figure 1: 2002 Gross Alpha Flux in pCi/s at BCK 11.97**

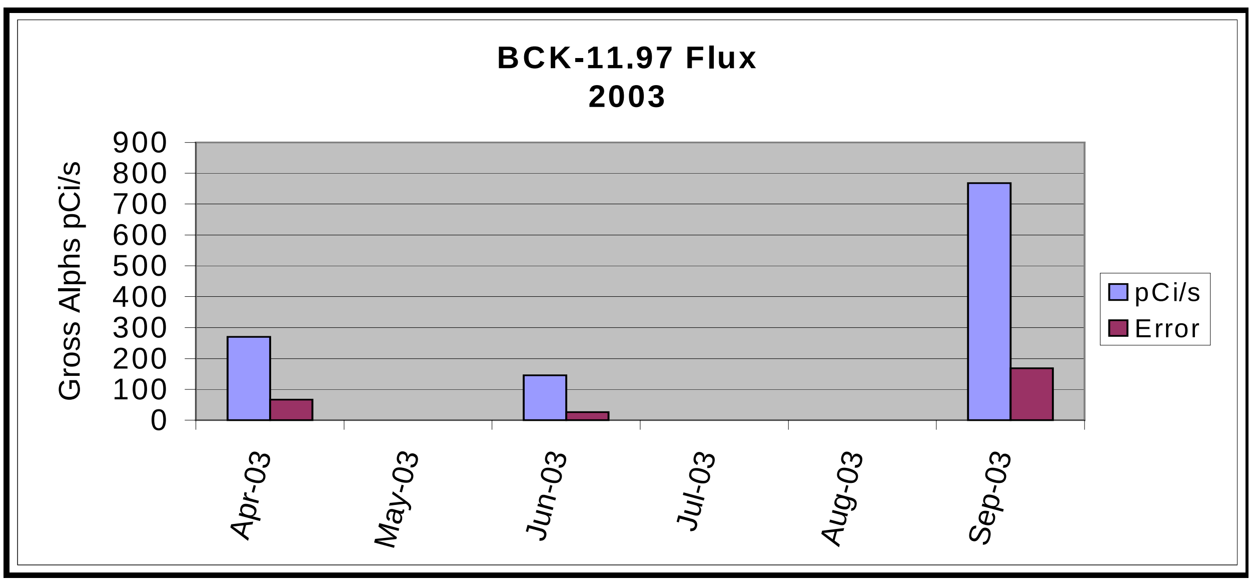



**Figure 2: 2003 Gross Alpha Flux in pCi/s at BCK 11.97**

However, this does not necessarily indicate that remediation efforts were successful in reducing the overall amount of uranium migrating through the valley. During the Boneyard-Burnyard excavation, NT-3 was diverted below the BCK 11.9 sampling point. When Bear Creek Valley receives significant rainfall, the waters of NT-3 just above BCK 11.97 have been observed to be extremely turbid. While it is difficult to obtain samples when the creek waters are at the stage where considerable turbidity is observed, it is expected that the greatest transport of uranium contamination occurs at this time. In the central portions of the study area at BCK 7, the flux of gross alpha has shown a significant increase during 2003. As can be seen in Figures 3 and 4, the flux of gross alpha in 2002 ran between 200 and 1000 pCi/s; in 2003 the flux tended to be between 3000 and 4000 pCi/s.

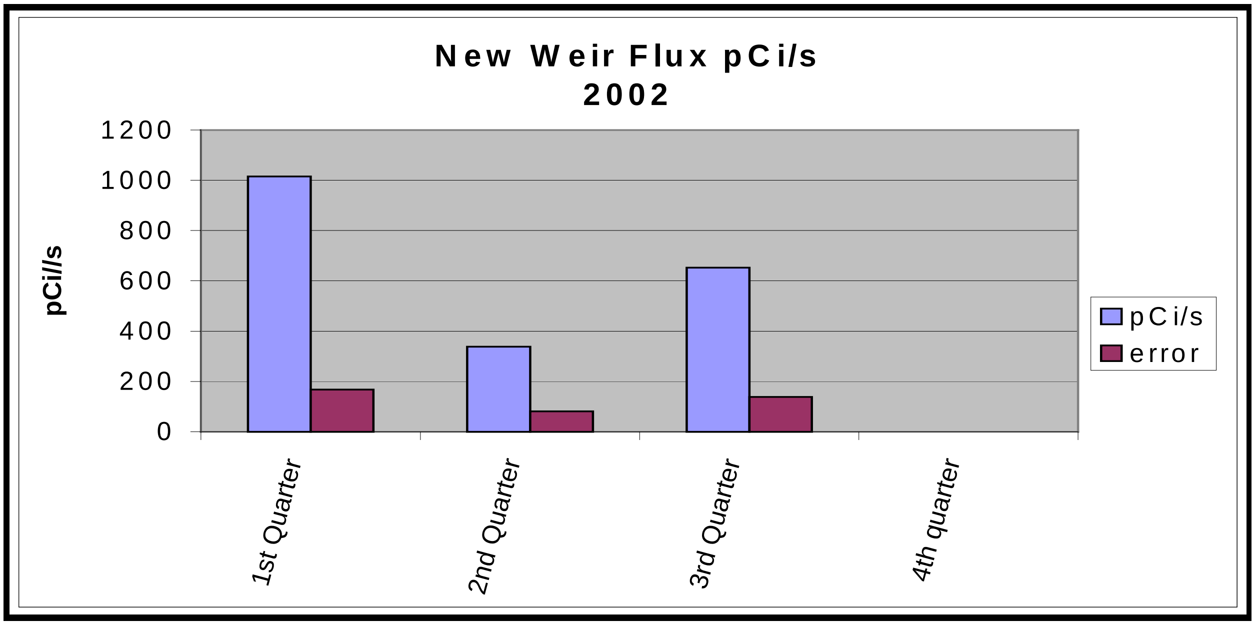



**Figure 3: 2002 Gross Alpha Flux in pCi/s at BCK 7.0**

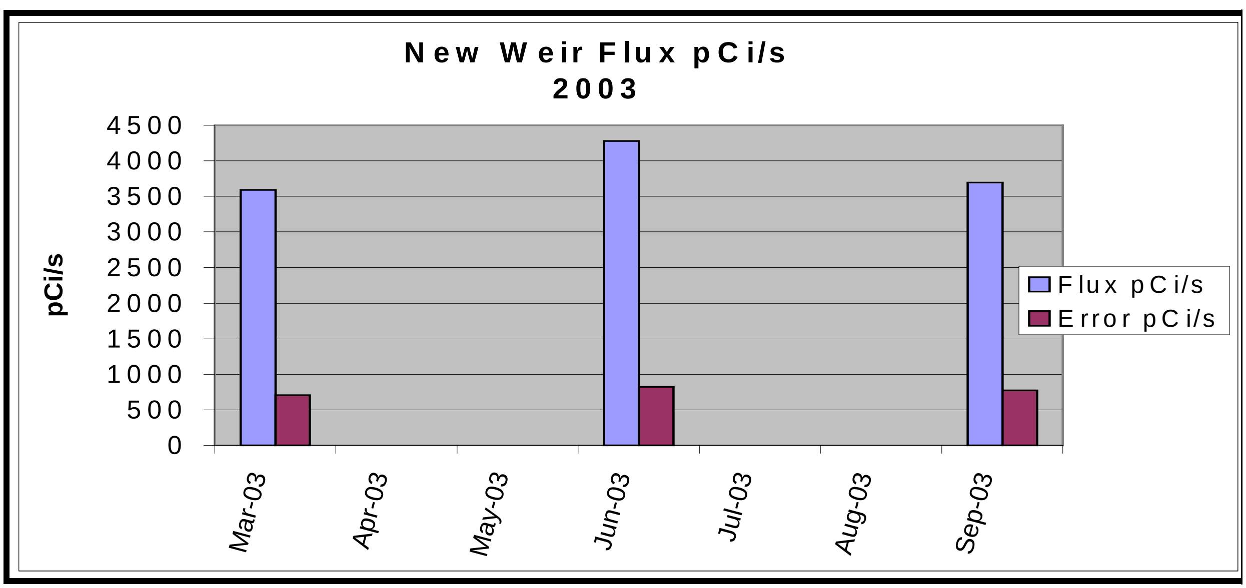



**Figure 4: 2003 Gross Alpha Flux in pCi/s at BCK 7.0**

While a temporary increase in the transport of contaminants can be expected during remedial activities, the significant increases seen in 2003 are probably attributable to the lack of adequate erosion control, as evidenced by the turbidity observed in NT-3 and Bear Creek just below NT-3. It is suggested that sediments laden with uranium have migrated from the remedial action into Bear Creek and that dissolution of the uranium from these excess sediments are responsible for the increase in gross alpha flux seen in the Bear Creek. Observing the terminal end of the study area at BCK-4.55, an increase in the flux of gross alpha can be noted when compared with 2002 data. The 2003 flux was between 900 and 2400 pCi/s, while 2002 results were all less than 400 pCi/s and some were significantly less under 25 pCi/s.

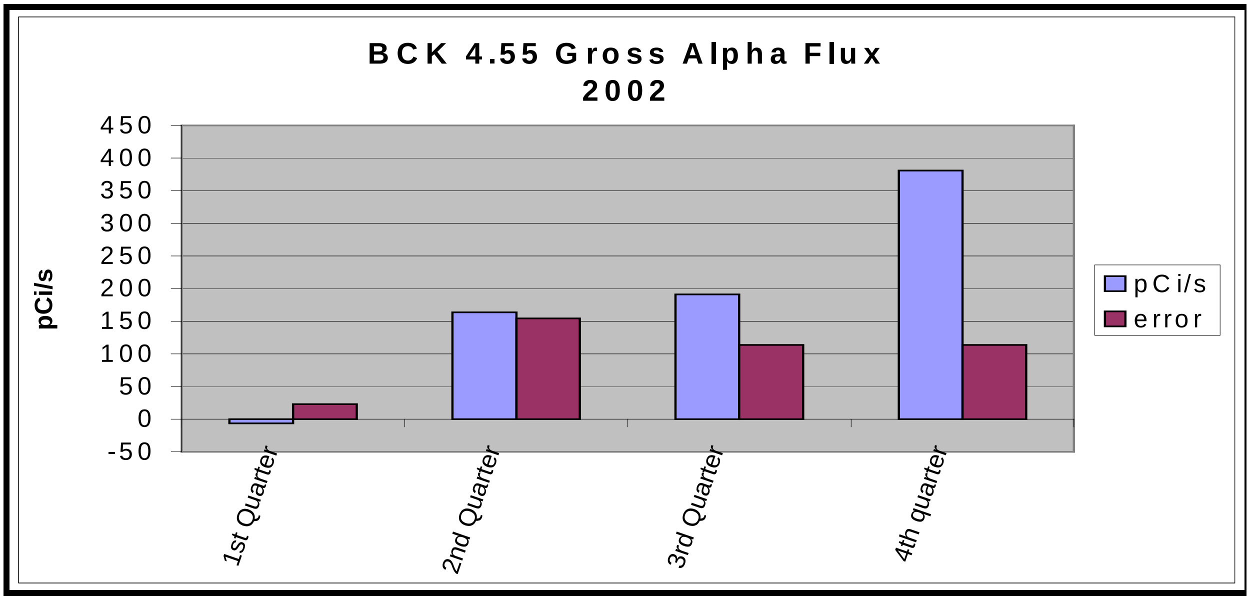



**Figure 5: 2002 Gross Alpha Flux in pCi/s at BCK 4.55**

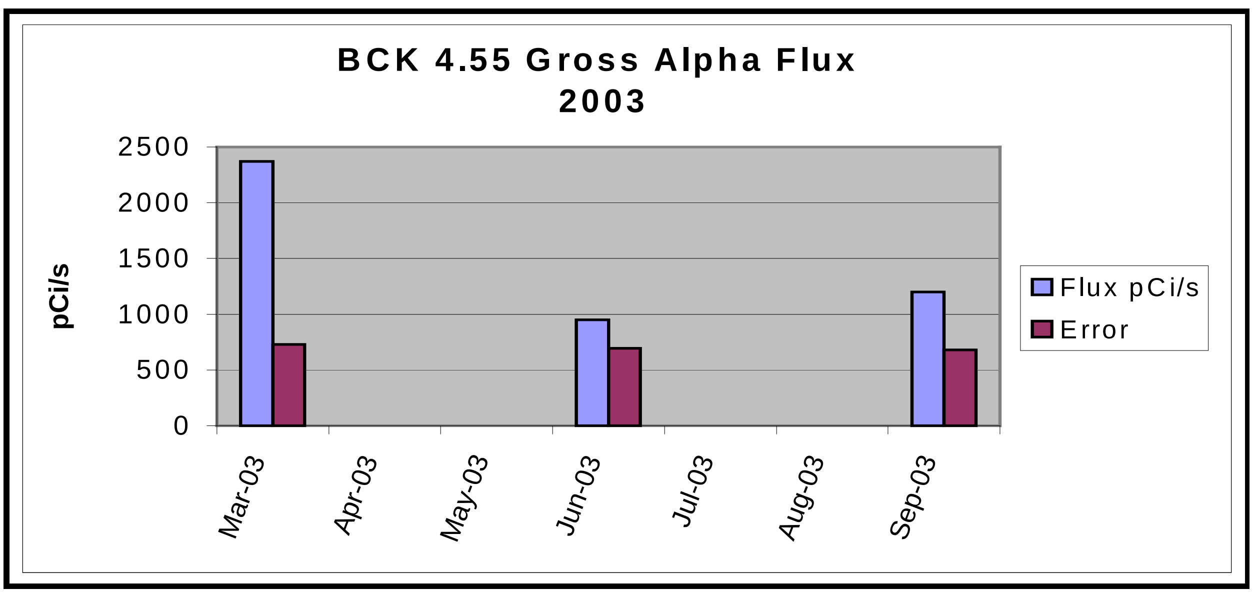



**Figure 6: 2003 Gross Alpha Flux in pCi/s at BCK 4.55**

As in 2002, the flux of uranium dissipates between BCK 7.00 (at the new weir) and BCK 4.55. It is believed that this is due to a combination of uranium coming out of solution and a loss of uranium bearing waters to the deeper groundwater system that has been observed in picket wells in Bear Creek Valley. In general, the observed behavior of the flux of gross alpha in the valley following the remediation of Boneyard-Burnyard is not promising. Any great lose of sediments from the source area may represent the development of a new source in the sediments deposited in and around Bear Creek.

*Springs:* In 2003, springs in Bear Creek Valley tended to behave in a manor consistent with that observed in 2002. Springs acted as a series of overflows for the Bear Creek subsurface karst aquifer. In periods of low rainfall, gross alpha fluxes were seen to increase relative to springs farther down the valley. Conversely, in periods of higher rainfall the subsurface system tended to fill up and waters laden with uranium tended to reemerge higher in the valley.

Rainfall in 2003 was abundant and gross alpha fluxes were seen to increase in springs as far up the valley as SS-4 and SS-5, while fluxes at SS-6, SS-7 and SS-8 decreased compared to 2002. However, it should be noted that sampling at SS-7 and SS-8 became impossible in the later half of the year, due to inundation caused by beavers.

While the contribution of uranium to the surface waters in Bear Creek Valley by springs in 2003 remained constant, the overall impact of spring borne contamination was insignificant compared to the increases seen in the surface waters. If this increase was attributable to larger amounts of soils washed into the creek from remedial projects, there is a possibility that as the soils are incorporated into the subsurface regime the springs will become an increasing source of gross alpha contamination in the Bear Creek surface system.

Another facet of sampling at springs involved analysis intended to establish background concentrations for a number of radionuclides that may be produced in operations at the Spallation Neutron Source (SNS), located on Chestnut Ridge. It is known from dye and sediment tracing that the area on which the SNS is located discharges into the subsurface and eventually into spring SS-5. In 2003, spring SS-5 was analyzed for carbon-14, clorine-36, iodine-129, tritium, and gamma-emitting radionuclides. None of the radionuclides in the background analysis were reported above detection limits.

*Tributaries*: While NT-3 was the primary contributor of uranium to Bear Creek in 2001, data indicate tributaries NT-3, NT-4 and NT-5 were not major contributors to the gross alpha flux in 2003. Although, this reduction in contaminant input may be misleading, since the remediation effort seems to have diverted and increased the uranium traveling through the Bear Creek system as shown by the measured increase in the flux downstream.

Both NT-3 and NT-5 were observed to be transporting extremely turbid waters into the Bear Creek after periods of heavy rainfall. Turbidity from these sources was observed to occlude Bear Creek waters as far downstream as Highway 95 at various times of the year. It is suspected that NT-3 becomes a significant contributor to the creek's radiochemical burden when turbidity is present. Unfortunately, during periods of high turbidity, NT-3 is impossible to sample. Therefore, it is suggested that a bias is inadvertently present regarding monitoring of NT-3.

NT-5 drains the recently constructed Environmental Management Waste Management Facility and was selected to be analyzed for an extended sweet of radiochemicals. The tributary was sampled for carbon-14, clorine-36, iodine-129, tritium, and gamma nuclides as well as gross alpha and gross beta. Unlike 2002, no unexpected gross alpha or gross beta results were obtained. The only positive results were for tritium. While positive, these results were several orders of magnitude beneath drinking water standards.

*Gross Alpha Flux in the Bear Creek Hydrological System:* In 2003, the study results suggested that anthropomorphic changes significantly altered the movement of gross alpha contamination in the waters of Bear Creek Valley. In general, the system of transport remained the same as had been observed in 2001 and 2002. Uranium originating from disposal areas in upper Bear Creek moved into the creek and subsurface drainage through discrete pathways such as NT-3 and JES's Seep. The gross alpha contaminant mass then follows the gaining and losing reaches of Bear Creek, being lost to the stream in dolines such as the one located at BCK 11.0 and various other fractures and/or conduits that exist on the stream bed. It appears that much of the contaminant "lost" from Bear Creek emerges in the series of springs along the base of the northern slope of Chestnut Ridge (in particular springs SS-4 and SS-5) and presumably in gaining reaches of Bear Creek itself. Some of the contaminant mass is probably lost to the deeper Maynardville Aquifer and has been detected from time to time in deep picket wells in this formation. Bear Creek from spring SS-6 (BCK 7) to Highway 95 (BCK 4.6) exhibits a considerable decrease in the gross alpha flux. This is presumably due to the continued neutralization of waters bearing dissolved uranium and the continued loss of contaminant bearing waters to the deeper portions of the Maynardville Aquifer.

The significant change noted in 2003 was the increase in the flux of gross alpha seen in Bear Creek itself. It is suggested that inadequate erosion control associated with remedial activities at Boneyard-Burnyard is responsible for the increases. However, due to the difficulties in sampling NT-3 this effect cannot be demonstrated. It is apparent that input from NT-3 either occurred during times of high water and increased turbidity or the contaminant was channeled elsewhere into Bear Creek or both. If sediment from Boneyard-Burnyard is the source of the increased gross alpha flux, then it is possible that a new source term has been created.

**Conclusions**

Most of the uranium in Bear Creek is delivered along discrete, low-volume, high-concentration flows, during the wetter parts of the year (NT-3 and JES's Seeps are particular problems). This suggests that uranium inputs to the creek can be identified and controlled.

Once in the creek, uranium transport mimics the karst conduit mixed surface and subsurface drainage of the Maynardville Limestone, reemerging in the springs along Chestnut Ridge (after being diluted with water from the Knox Aquifer) and in springs that are intregal to the bed of Bear Creek itself. This process of reemergence is substantially completed around spring SS-6 with greatly diminished gross alpha fluxes at SS-7 and SS-8, except during the dryer parts of the year when a lower flow regime dominates the karst system. Between the point where SS-6 drains into Bear Creek (approximately BCK 7) and Highway 95 (BCK 4.6) the flux of uranium decreases, presumably due to neutralization of the dissolved phase and loss to the deeper aquifer.

The chief difference between 2002 and 2003 data was the greater flux seen in lower Bear Creek and the movement of larger gross alpha fluxes to springs located higher in the valley. This movement up the valley reflects the overflow nature of the spring system in Bear Creek Valley and the increase in rainfall seen during 2003. The increase fluxes in the lower reaches of Bear Creek in the study area probably reflect the input of uranium laden sediments into Bear Creek as a result of turbid waters from the Boneyard-Burnyard remediation. Whether the contaminant laden sediments have adversely affected the subsurface drainage in Bear Creek Valley is not apparent from this year's data and may require several more years monitoring before any such effect is seen.

**References**

AJA Technical Services INC. 2000. *Y-12 Plant Groundwater Protection Program Groundwater and Surface Water Sampling and Analysis Plan for Calendar Year 2001*. September 2000

Hatcher, et al.1992. *Status Report on the Geology of the Oak Ridge Reservation,* ORNL/TM-12074, Environmental Sciences Division Pub. No. 3860. October 1992

Robinson, John A. and Johnson, Gregory C. *Results of Seepage Investigation at Bear Creek Valley, Oak Ridge, Tennessee January through September 1994* U.S. U.S. Geological Survey, Open-File Report 96-459

Robinson, John A. and Mitchell, Reavis L. III. *Gaining, Losing, and Dry Stream Reaches at Bear Creek Valley, Oak Ridge, Tennessee March and September 1994*_U.S. Geological Survey, Open-File Report 96-557

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement. Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Tennessee Department of Environment and Conservation, 2002. *Tennessee Department of Environment and Conservation, Department of Energy Oversight Division Environmental Monitoring Plan January through December 2001.* Oak Ridge, Tennessee.

U.S. Environmental Protection Agency Region IV Environmental Services Division. 1991. *Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual*. February 1991.

Yard, C.R., 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

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# CHAPTER 6 SURFACE WATER MONITORING

## Ambient Sediment Monitoring Project

Principle Author: John G. Peryam

**Abstract**

Sediment analysis is a key component of environmental quality and impact assessment for aquatic ecosystems. The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducted sediment sampling at 34 sites in 2003. The sediments were analyzed for inorganics, organics, and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations Office. Based on the designation of the water bodies involved, the values were compared to the recreational PRGs. Under recreational land use, individuals are assumed to be exposed to contaminated media while playing, fishing, hunting, or engaging in other outdoor activities. Exposure could result from ingestion of soil or sediment, inhalation of vapors from soil or sediment, dermal contact with soil or sediment, external exposure to ionizing radiation emitted from contaminants in soil or sediment, and consumption of fish. Based on this comparison, the sediments showed no levels of concern for human health.

**Introduction**

Many organisms depend upon sediments as their primary habitat. Man-made chemicals and waste materials introduced into aquatic systems are often accumulated in sediments. Sediment analysis is an important aspect of environmental quality and impact assessment for rivers, streams, and lakes. The Tennessee Department of Environment and Conservation, Department of Energy Oversight Division (the division) conducts an ambient sediment monitoring program that monitors 34 sites annually for the purpose of detecting possible contamination from DOE sites. There are 11 sites on the Clinch River and 2 on the Tennessee River near the mouth of the Clinch River. Site 2 is a background site and is located upstream of the Oak Ridge Reservation (ORR). Tributaries of the Clinch River make up the other 21 sampling sites. Two of the tributary sites (24, 25) are located upstream of the ORR and serve as background sites.

Sampling was conducted in 2003 during April and May. Samples were analyzed for inorganic, organic and radiological parameters. Since there are no federal or state sediment cleanup levels, the data were compared to the Department of Energy's (DOE) Preliminary Remediation Goals (PRGs) for use at the Department of Energy Oak Ridge Operations Office. The PRGs are human health risk assessment figures that are dynamic in nature, changing as new information becomes available. Data are available on request.

**Methods and Materials**

Sediment samples were taken during April and May using the methods described in the 2003 Ambient Sediment Monitoring Plan. Samples were collected at locations with fine sediments; rocky or sandy areas were not used. River sediment samples were taken with a petite ponar dredge; stream samples were taken with stainless steel spoons. The Tennessee state laboratory processed the samples, according to EPA approved methods.

Analytical Parameters

*Inorganics:* aluminum, arsenic, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, and zinc.

*Organics (extractables):* butyl benzyl phthalate, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, di-n-octyl phthalate, diethyl phthalate, dimethyl phthalate, n-nitrosodimethylamine, n-nitrosodiphenylamine, n-nitroso-di-n-propylamine, isophorone, nitrobenzene, 2,4-dinitrotoluene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, napthalene, phenanthrene, pyrene, chrysene, bis(2-chloroethyl) ether, bis(2-chloroethoxy)methane, bis(2-chloroisopropyl) ether, 4-bromophenylphenyl ether, 4-chlorophenylphenyl ether, hexachlorocyclopentadiene, hexachlorobutadiene, hexachlorobenzene, hexachloroethane, 1,2,4-trichlorobenzene, 2-chloronapthalene, 4-chloro-3-methylphenol, 2-chlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-methyl-4,6-dinitrophenol, 2-nitrophenol, 4-nitrophenol, pentachlorophenol, phenol, 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, pyridine, o-cresol, m & p cresol, 2-methylnaphthalene, 4-chloroaniline, dibenzofuran, 3,3-dichlorobenzidine, 2-nitroaniline, 3-nitroaniline, 4-nitroaniline, aldrin, alpha-BHC, beta-BHC, delta-BHC, gamma-BHC (lindane), alpha-chlordane, gamma-chlordane, technical chlordane, p,p-DDD, p,p-DDE, p,p-DDT, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, heptachlor, heptachlor epoxide, toxaphene, methoxychlor, PCB 1016/1242, PCB 1221, PCB 1232, PCB 1248, PCB 1254, PCB 1260, PCB 1262, carbazole, acetophenone, benzaldehyde, 1,1'-biphenyl, and caprolactam.

*Radiological:* gross alpha, gross beta, and gamma radionuclides.

Sampling Stations

*Site 2 – Clinch River Mile 52.6:* Samples are taken in an area approximately 20 to 40 feet from the west bank of the river. This site is upstream of any possible DOE impacts and is a reference site in this respect. It may, however, show effects of any agricultural, industrial and residential activities upstream. (See Figure 1.4)

*Site 3 - Melton Hill Park:* Samples are taken in an area approximately 40 feet from the west bank of the river. (See Figure 1.3)

*Site 4 - Grubb Islands:* Samples are taken in an area approximately 20 to 40 feet from the west bank of the island (downstream side) on the inside of the bend in the river. The coordinates are approximately 35º 53' 52" N latitude and -84º 22' 24" W longitude. (See Figure 1.2)

*Site 5 - Brashear Island:* Samples are taken in an area approximately 20 to 40 feet south of the last sandbar (going downstream) of the river approximately 300 to 400 feet upstream of Brashear Island. The coordinates are approximately 35º 55' 13" N latitude and -84º 26' 02" W longitude. (See Figure 1.1)

*Site 6 - Bull Run Steam Plant:* Samples are taken at the upstream end of the skimmer wall. The coordinates are approximately 36º 01' 28" N latitude and -84º 10' 02" W longitude. (See Figure 1.4)

*Site 7 – Clinch River Mile 41.2:* Samples are taken in the shallows on the inside of the bend in the river. (See Figure 1.3)

*Site 8 - Scarboro Creek:* Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and -84º 13' 00" W longitude. (See Figure 1.3)

*Site 9 - Kerr Hollow Branch:* Samples are taken about 200 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and -84º 13' 37" W longitude. (See Figure 1.3)

*Site 10 - McCoy Branch:* Samples are taken underneath the power lines just upstream from Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and -84º 14' 54" W longitude. (See Figure 1.3)

*Site 11 - Western Branch:* Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 00" N latitude and -84º 15' 05" W longitude. (See Figure 1.3)

*Site 12 - East Fork of Walker Branch:* Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 57' 22" N latitude and -84º 15' 58" W longitude. (See Figure 1.3)

*Site 13 - Bearden Creek:* Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and -84º 17' 01" W longitude. (See Figure 1.3)

*Site 14 – Unnamed Stream:* Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 25" N latitude and -84º 16' 39" W longitude. (See Figure 1.3)

*Site 15 – Unnamed Stream:* Samples are taken about 75 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 21" N latitude and -84º 17' 06" W longitude. (See Figure 1.3)

*Site 16 – Unnamed Stream:* Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 53' 22" N latitude and -84º 18' 04" W longitude. (See Figure 1.2)

*Site 17 – Unnamed Stream:* Samples are taken about 2000 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and -84º 20' 12" W longitude. (See Figure 1.2)

*Site 18 - Raccoon Creek:* Samples are taken about 1500 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and -84º 21' 05" W longitude. (See Figure 1.2)

*Site 19 - Ish Creek:* Samples are taken about 1500 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and -84º 21' 33" W longitude. (See Figure 1.2)

*Site 20 - Grassy Creek:* Samples are taken about 200 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and -84º 22' 55" W longitude. (See Figure 1.2)

*Site 21 – Unnamed Stream:* Samples are taken about 75 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and -84º 22' 57" W longitude. (See Figure 1.2)

*Site 22 – Unnamed Stream:* Samples are taken approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and -84º 23' 25" W longitude. (See Figure 1.2)

*Site 23 – Ernie's Creek:* This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance upstream of the Clinch River embayment at Clinch River Mile 51.1. The approximate coordinates are 36º 02' 19" N latitude and -84º 12' 47" W longitude. (See Figure 1.4)

*Site 24 – White Creek:* This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about one mile upstream of Norris Lake/Clinch River. The approximate coordinates are 36º 20' 47" N latitude and -83º 53' 42" W longitude. (See Figure 1.6)

*Site 25 – Clear Creek:* This stream is located near Norris Dam near Clinch River Mile 77.7. Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12' 49" N latitude and -84º 03' 33" W longitude. This is a background site. (See Figure 1.5)

*Site 26 – Clinch River Mile 9.0:* Samples are taken just upstream of rock cliffs and downstream of where a creek empties into the river, on the inside of the bend in the river. The coordinates are approximately 35º 54' 36" N latitude and -84º 26' 15" W longitude. (See Figure 1.1)

*Site 27 – Clinch River Mile 7.0:* Samples are taken just upstream of where a creek empties into the river, on the inside of the bend in the river. The coordinates are approximately 35º 53' 37" N latitude and -84º 27' 46" W longitude. (See Figure 1.1)

*Site 28 – Clinch River Mile 4.0:* Samples are taken near a small island (heron rookery) just downstream of the mouth of the Emory River. The coordinates are approximately 35º 53' 29" N latitude and -84º 29' 55" W longitude. (See Figure 1.1)

*Site 29 – Clinch River Mile 0 .0:* Samples are taken near the pole with the green beacon in about 10 feet of water. The coordinates are approximately 35º 51' 52" N latitude and -84º 32' 01" W longitude. (See Figure 1.1)

*Site 30 – Tennessee River Mile 569 (one mile upstream of Clinch River mouth):* The coordinates are approximately 35º 50' 43" N latitude and -84º 32' 23" W longitude. (See Figure 1.1)

*Site 31 – Tennessee River Mile 567 (one mile downstream of Clinch River mouth):* The coordinates are approximately 35º 51' 38" N latitude and -84º 32' 38" W longitude. (See Figure 1.1)

*Site 32 – Clinch River Mile 19.7 (below Jones Island):* The coordinates are approximately 35º 54' 03" N latitude and -84º 21' 02" W longitude. (See Figure 1.2)

*Site 33 – Poplar Creek Mile 0.5:* The coordinates are approximately 36º 01' 03" N latitude and -84º 14' 21" W longitude. (See Figure 1.1)

*Site 34 – Walker Branch:* The coordinates are approximately 35º 57' 10" N latitude and -84º 16' 25" W longitude. (See Figure 1.3)

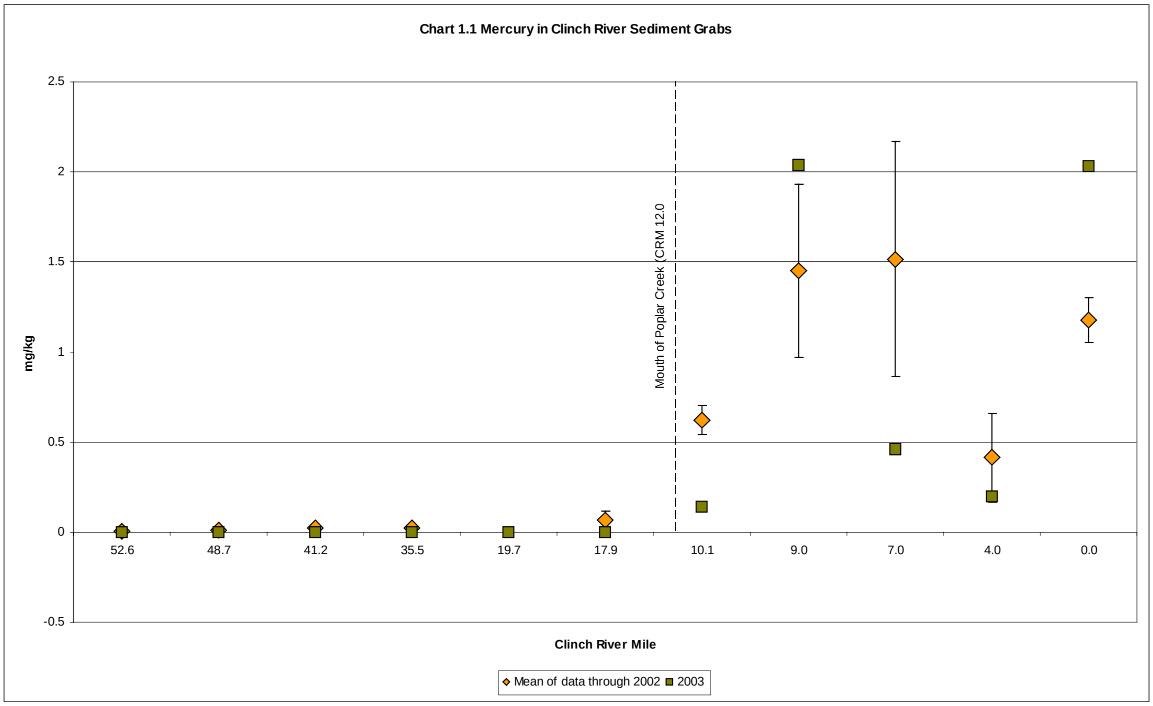
*Site 35 – Unnamed Stream:* The coordinates are approximately 35º 54' 04" N latitude and -84º 21' 59" W longitude. (See Figure 1.2)

## Results and Discussion

### Inorganics Analyses

Inorganic analyses of sediment samples taken in 2003 showed no levels of concern based on comparisons with DOE's Preliminary Remediation Goals (PRGs) for recreation use of soils and sediments. PRGs are used for comparison because there are no state or federal sediment criteria.

Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek (sites 5, 26, 27, 28, and 29: river miles 10.1, 9.0, 7.0, 4.0, and 0.0, respectively) increase as one goes downstream. Although the levels of mercury are well below the recreational PRG (780 mg/kg), they are higher than all of the other sediment sampling sites (see Chart 1.1). Mercury is virtually undetectable at the sites upstream of the mouth of Poplar Creek; this is why the data points for the means are obscured by the 2003 data points at Clinch River Miles (CRM) 52.6, 48.7, 41.2, 35.5 and 17.9.




## Organics Analyses

The Clinch River samples had no detectable levels of organics; the tributaries showed occasional trace amounts of polycyclic aromatic hydrocarbons (PAHs). The amounts seen can be attributed to decaying organic matter in the sediments. The organics results show no reason for concern.

## Radiological Analyses

The radiological sediment data show no reason for concern; all parameters are well below DOE PRGs. In the Clinch River, Cs-137 levels are typically higher in samples taken downstream of the mouth of White Oak Creek than those taken upstream (see Chart 1.2). Cs-137 is virtually undetectable at all of the sites upstream of the mouth of White Oak Creek; this is why the means are obscured by the 2003 data points in the chart at CRM 41.2 and 35.5.

Tributary samples taken near ORNL (CRM 27.0) and downstream appear to have higher levels of Cs-137 than samples taken upstream of CRM 27.9 (See Chart 1.3). In both cases, the amounts are very low and do not pose a threat to human health. The recreational PRG for Cs-137 is 270,000 pCi/g. Site 22 (CRM 14.45) has shown significantly higher levels of Cs-137 than all of the other sites. It is not shown in Chart 1.5 because it distorts the perspective for the other sampling sites. The mean for Cs-137 at site 22 (based on 3 samples taken between 1997 and 2002) is 16.32 pCi/g (standard error 4.37). The value for 2003 was 9.40 ± 0.14 pCi/g. This stream runs through the K-1515C lagoon that was once used to receive backwash material from filters at the ETTP Water Treatment Plant. It is believed that these water filters concentrated the Cs-137 from suspended river sediments. The K-1515C lagoon is no longer used for the purpose of catching filter backwash material.

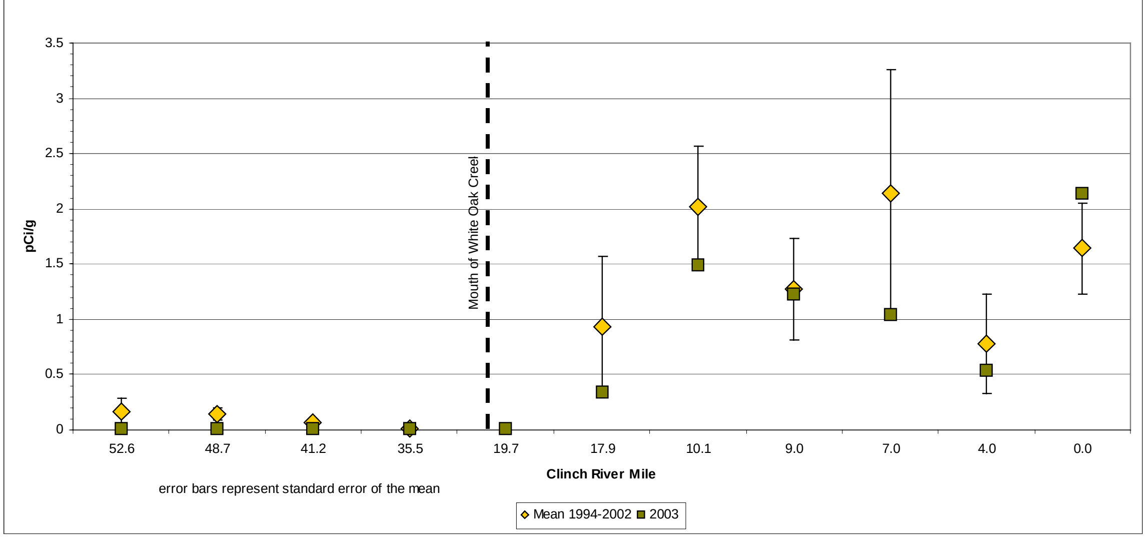



**Chart 1.2 Cs-137 in Clinch River Sediment Grabs**

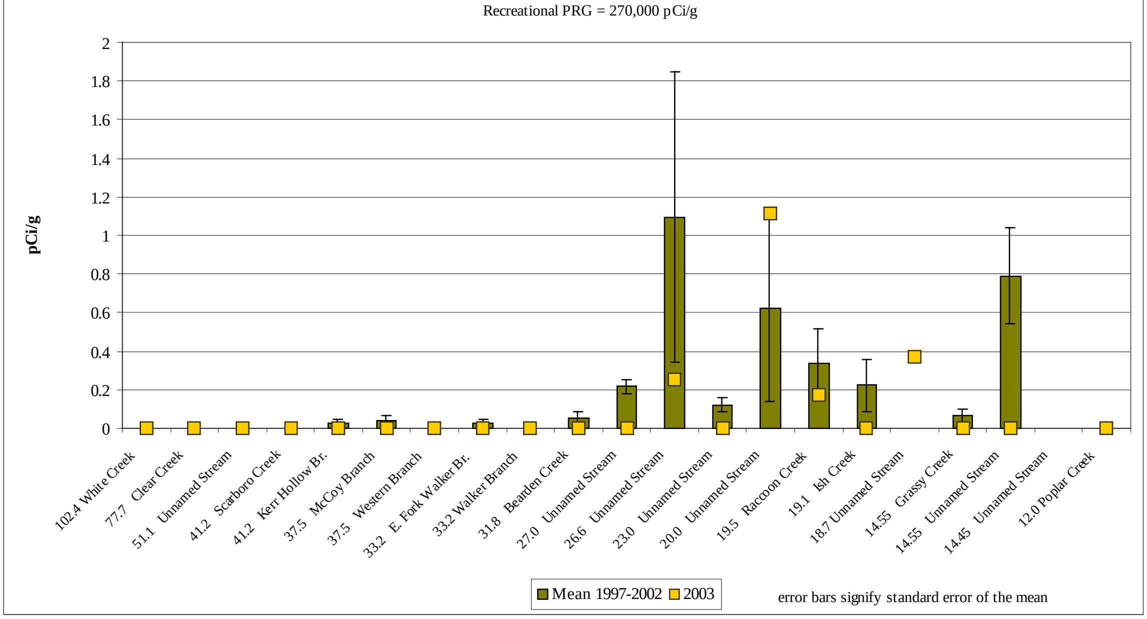



**Chart 1.3 Cs-137 in Clinch River Tributary Sediment Grabs**

## Conclusion

Sediment data from 2003 samplings show no levels of contamination that exceed DOE Preliminary Remediation Goals (PRGs) for recreation and based on these criteria do not pose a threat to human health. If in the future, these sediments are to be used for agricultural and/or other purposes, analysis may be performed to determine the suitability for these new purposes. Mercury levels in the samples taken in the Clinch River below the confluence of Poplar Creek increase as one goes downstream. Although the levels of mercury are well below the recreational PRG, they are higher than all of the other sediment sampling sites. Radiological data show a slight elevation in Cs-137 in samples taken near or downstream of ORNL as compared to upstream sampling sites. Site 22 (CRM 14.45) has shown considerably higher levels of Cs-137 than all of the other sites.

This is believed to be due to the effect of concentrating suspended Cs-137-contaminated sediment particles in river water by filters at the ETTP Water Treatment Plant and disposing of the filter backwash material in the K-1515C lagoon. This lagoon is no longer used for this purpose.

**Table 1.1 Sample Locations for Sediment in 2003:**

| Site | Location | Clinch River Mile |
|---|---|---|
| 2 | Clinch River Mile 52.6 | 52.6 |
| 3 | Melton Hill Park | 35.5 |
| 4 | Grubb Islands | 17.9 |
| 5 | Brashear’s Island | 10.1 |
| 6 | Bull Run Steam Plant | 48.7 |
| 7 | Clinch River Mile 41.2 | 41.2 |
| 8 | Scarboro Creek | 41.2 |
| 9 | Kerr Hollow Branch | 41.2 |
| 10 | McCoy Branch | 37.5 |
| 11 | Western Branch | 37.5 |
| 12 | East Fork Walker Branch | 33.2 |
| 13 | Bearden Creek | 31.8 |
| 14 | Unnamed Stream | 27.0 |
| 15 | Unnamed Stream | 26.6 |
| 16 | Unnamed Stream | 23.0 |
| 17 | Unnamed Stream | 20.0 |
| 18 | Raccoon Creek | 19.5 |
| 19 | Ish Creek | 19.1 |
| 20 | Grassy Creek | 14.55 |
| 21 | Unnamed Stream | 14.55 |
| 22 | Unnamed Stream | 14.45 |
| 23 | Ernie’s Creek | 51.1 |
| 24 | White Creek | 102.4 |
| 25 | Clear Creek | 77.7 |
| 26 | Clinch River Mile 9.0 | 9.0 |
| 27 | Clinch River Mile 7.0 | 7.0 |
| 28 | Clinch River Mile 4.0 | 4.0 |
| 29 | Clinch River Mouth | 0.0 |
| 30 | Tennessee River Mile 569 | n.a. |
| 31 | Tennessee River Mile 567 | n.a. |
| 32 | Jones Island | 19.7 |
| 33 | Poplar Creek | 12.0 |
| 34 | Walker Branch | 33.2 |
| 35 | Unnamed Stream | 18.7 |

**Figure 1.1: Sediment Monitoring Sites**

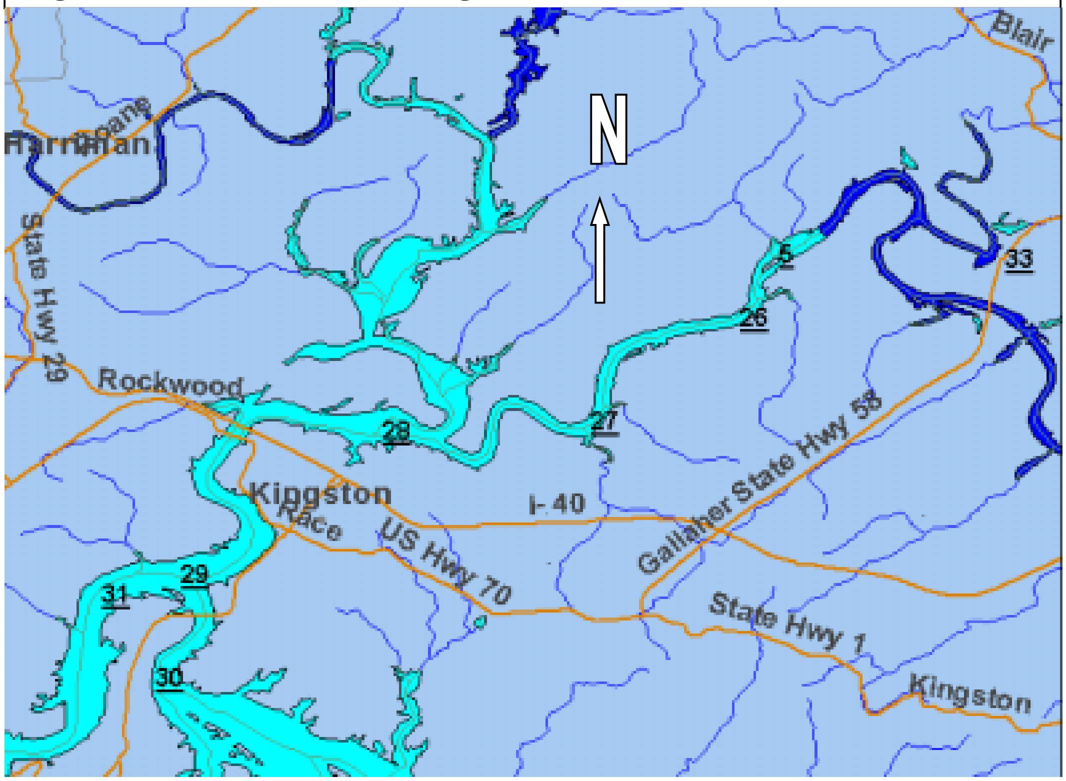



**Figure 1.2: Sediment Monitoring Sites**

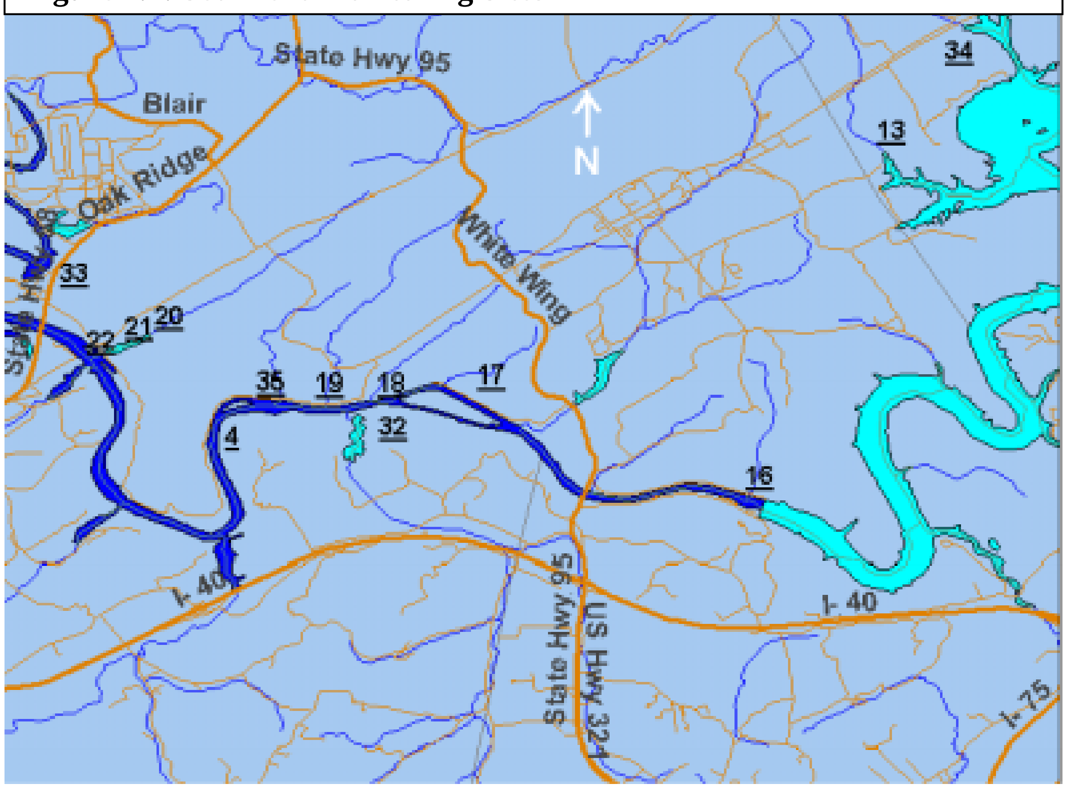


**Figure 1.3: Sediment Monitoring Sites**

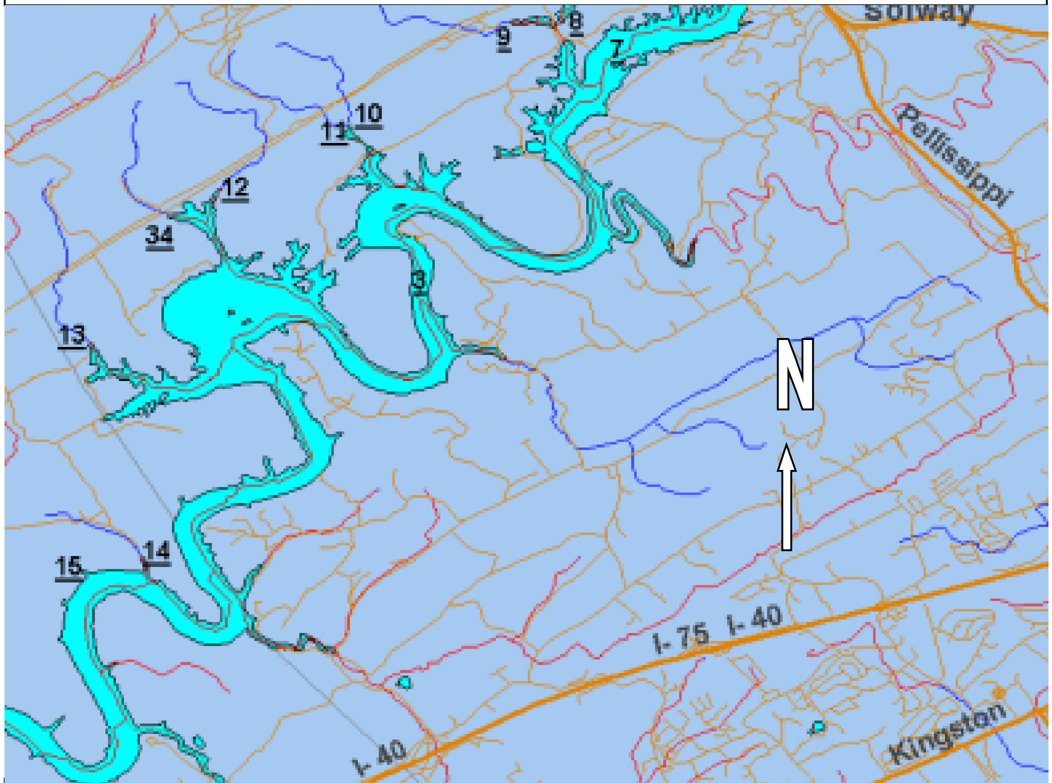



**Figure 1.4: Sediment Monitoring Sites**

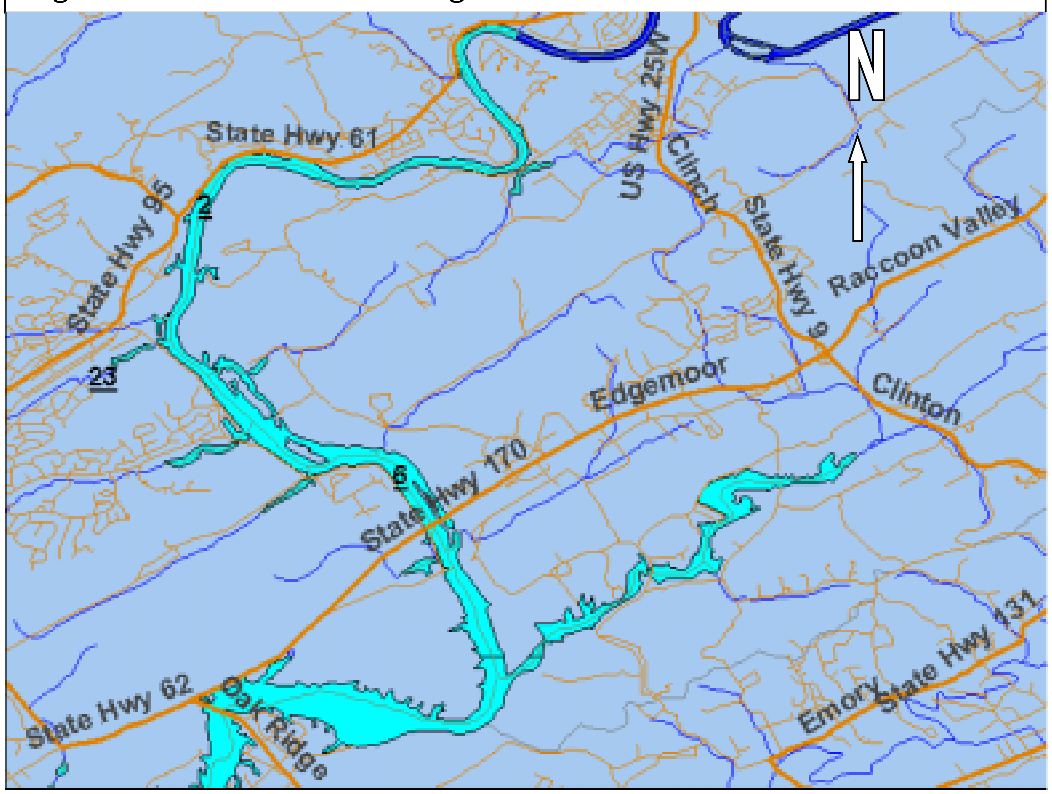


**Figure 1.5: Sediment Monitoring Sites**

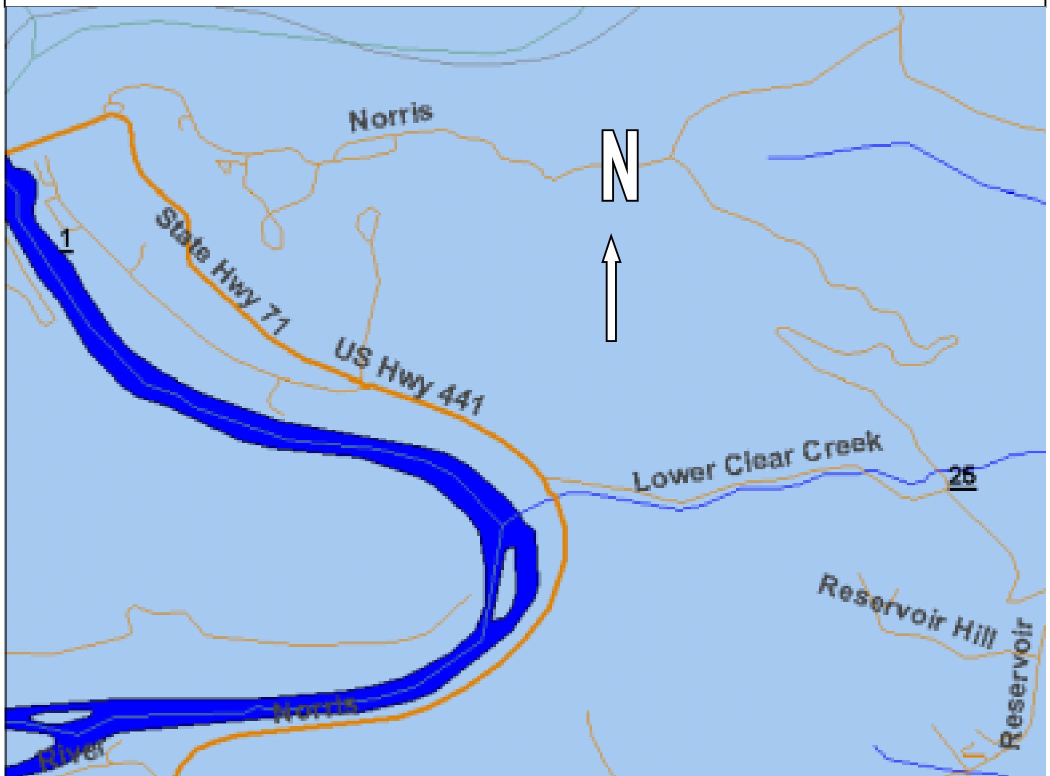
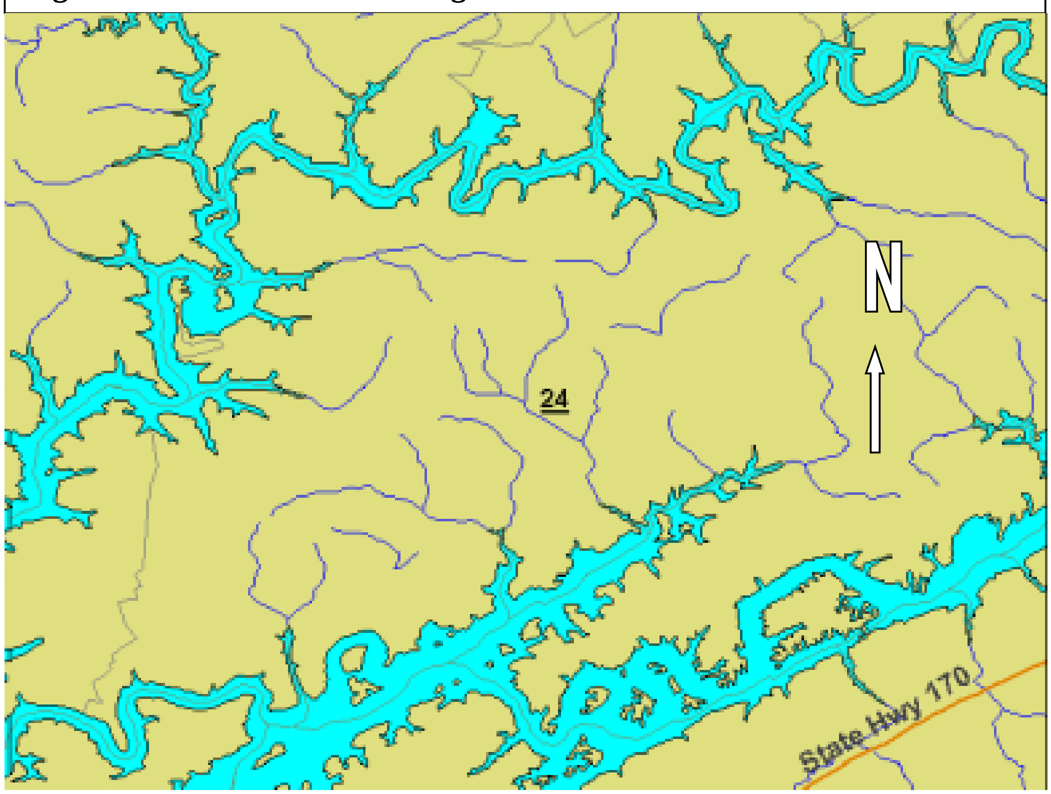



**Figure 1.6: Sediment Monitoring Sites**



**References**

ASTM (American Society for Testing and Materials). 1990. *Standard Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing*. E 1391-90. Philadelphia, Pennsylvania.

LMES (Lockheed Martin Energy Systems, Inc.). 1995. *Preliminary Remediation Goals for Use at the U. S. Department of Energy Oak Ridge Operations Office,* ES/ER/TM-106/R1, Oak Ridge, Tennessee.

TDEC DOEO (Tennessee Department of Environment and Conservation, Department of Energy Oversight). 1996. *Standard Operating Procedures*. Oak Ridge, Tennessee.

TDH (Tennessee Department of Health Laboratory Services). 1999. *Standard Operating Procedures.* Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee.* Oak Ridge, Tennessee.

Region IV (U.S. Environmental Protection Agency). 1991. *Environmental Compliance Standard Operating Procedures and Quality Assurance Manual*. Environmental Services Division, U.S. Environmental Protection Agency Region IV, Atlanta, Georgia.

Yard, C. R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation, Department of Energy Oversight Division. Oak Ridge, Tennessee.

# CHAPTER 6 SURFACE WATER MONITORING

## Ambient Surface Water Monitoring Program

Principle Author: John G. Peryam

**Abstract**

The DOE Oversight Division conducted surface water sampling at 26 sites on the Clinch River and its tributaries in 2003. The samples were analyzed for certain metals, nutrients, and physical parameters. The data show no exceedences of the Tennessee Water Quality Criteria (TWQC).

**Introduction**

The Tennessee Department of Environment and Conservation, DOE Oversight Division (the division) conducts an ambient surface water monitoring program that monitors 26 sites semi-annually for the purpose of detecting possible contamination from DOE sites. There are 8 sites on the Clinch River, two of which are background sites and are not affected by Oak Ridge Reservation operations. Tributaries of the Clinch River make up the other 18 sampling sites. Two of the tributary sites are located upstream of the Oak Ridge Reservation and serve as background data sites.

The Clinch River, being large and subject to dilution, is not expected to have high concentrations of pollutants in surface water grab samples. However, the sampling data do set up a baseline for comparison to previous sampling events. In the case of an unplanned release or an accident, the sampling data may help to reflect the amount and extent of pollution.

The sampling sites were sampled twice during 2003, once in April/May and in October. Samples were analyzed for E. coli, Enterococcus, ammonia, COD, dissolved residue, $NO_3$ & $NO_2$ nitrogen, suspended residue, total hardness, total kjeldahl nitrogen, total phosphate, arsenic, cadmium, copper, iron, lead, manganese, mercury, chromium, and zinc.

**Methods and Materials**

Surface water samples were taken during June/July and October using the methods described in the 2002 Ambient Surface Water Sampling Plan. The Tennessee Department of Health (TDH) Laboratories processed the samples, according to EPA approved methods.

**Results and Discussion**

Surface water quality in the Clinch River and tributaries sampled is good. None of the parameters sampled for exceeded Tennessee Water Quality Criteria (TWQC). Mercury has not been detected in any of the surface water samples (chart 1.1, 1.2). Arsenic is slightly elevated in McCoy Branch but is well below TWQC (chart 1.3). This arsenic is from the remediated Filled Coal Ash Pond. Arsenic is rarely found in river samples (Chart 1.4).

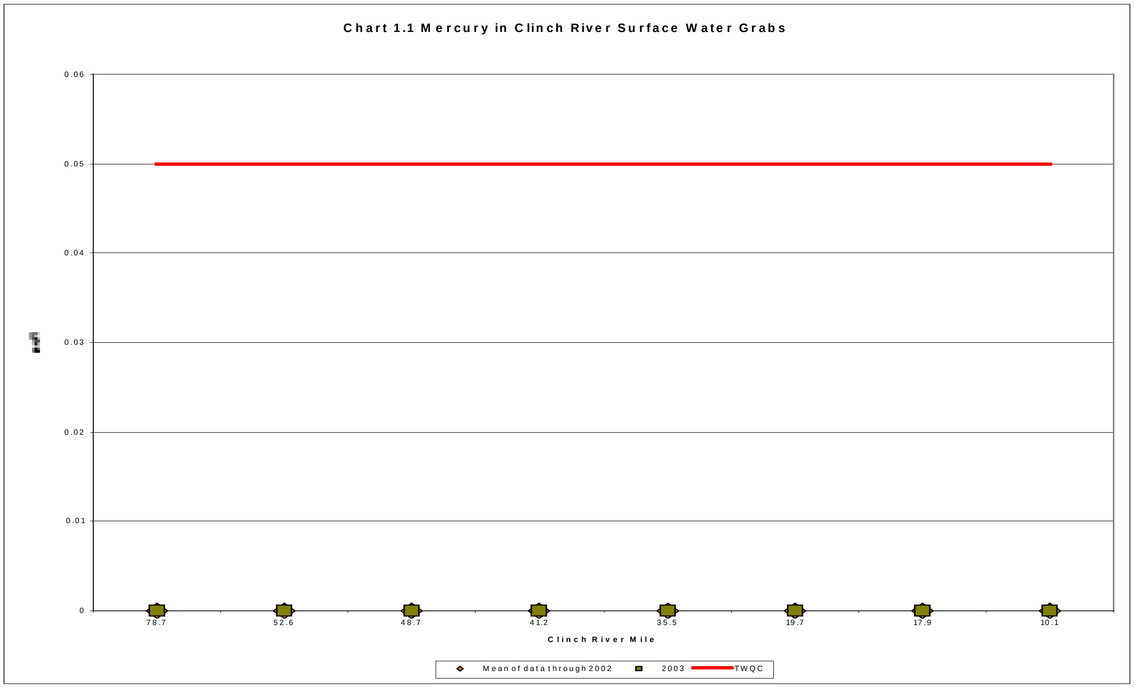


Chart 1.1 Mercury in Clinch River Surface Water Grabs
0.06
0.05
0.04
0.03
0.02
0.01
0
78.7
52.6
48.7
41.2
35.5
19.7
17.9
10.1
Clinch River Mile
Mean of data through 2002
2003
TWQC

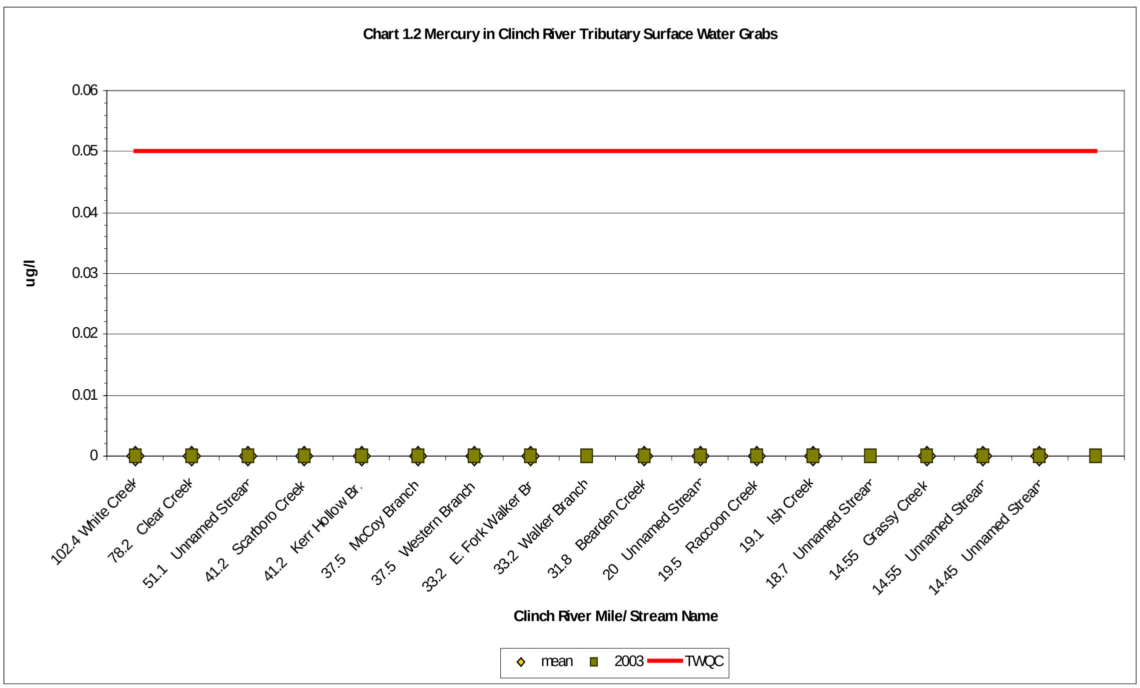


Chart 1.2 Mercury in Clinch River Tributary Surface Water Grabs
ug/l
0.06
0.05
0.04
0.03
0.02
0.01
0
102.4 White Creek
78.2 Clear Creek
51.1 Unnamed Stream
41.2 Scarboro Creek
41.2 Kerr Hollow Br.
37.5 McCoy Branch
37.5 Western Branch
33.2 E. Fork Walker Br
33.2 Walker Branch
31.8 Bearden Creek
20 Unnamed Stream
19.5 Raccoon Creek
19.1 Ish Creek
18.7 Unnamed Stream
14.55 Grassy Creek
14.55 Unnamed Stream
14.45 Unnamed Stream
Clinch River Mile/ Stream Name
mean
2003
TWQC

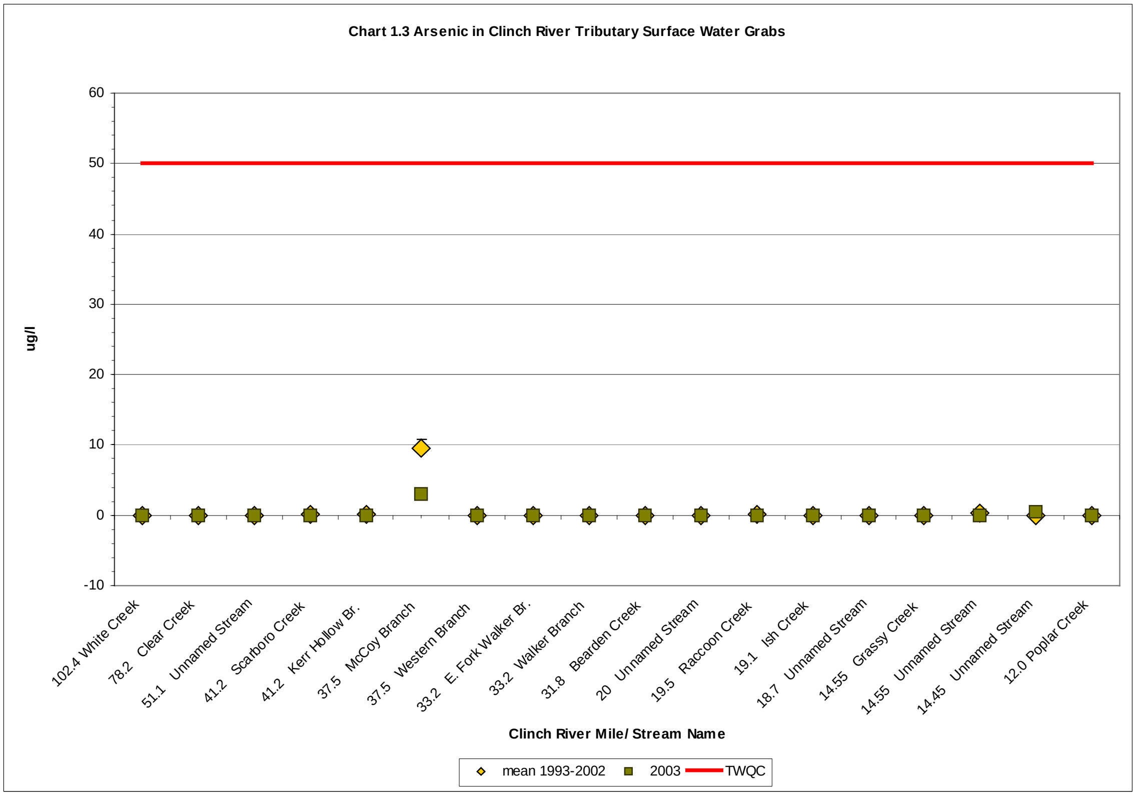


Chart 1.3 Arsenic in Clinch River Tributary Surface Water Grabs
ug/l
60
50
40
30
20
10
0
-10
102.4 White Creek
78.2 Clear Creek
51.1 Unnamed Stream
41.2 Scarboro Creek
41.2 Kerr Hollow Br.
37.5 McCoy Branch
37.5 Western Branch
33.2 E. Fork Walker Br.
33.2 Walker Branch
31.8 Bearden Creek
20 Unnamed Stream
19.5 Raccoon Creek
19.1 Ish Creek
18.7 Unnamed Stream
14.55 Grassy Creek
14.55 Unnamed Stream
14.45 Unnamed Stream
12.0 Poplar Creek
Clinch River Mile/ Stream Name
mean 1993-2002
2003
TWQC

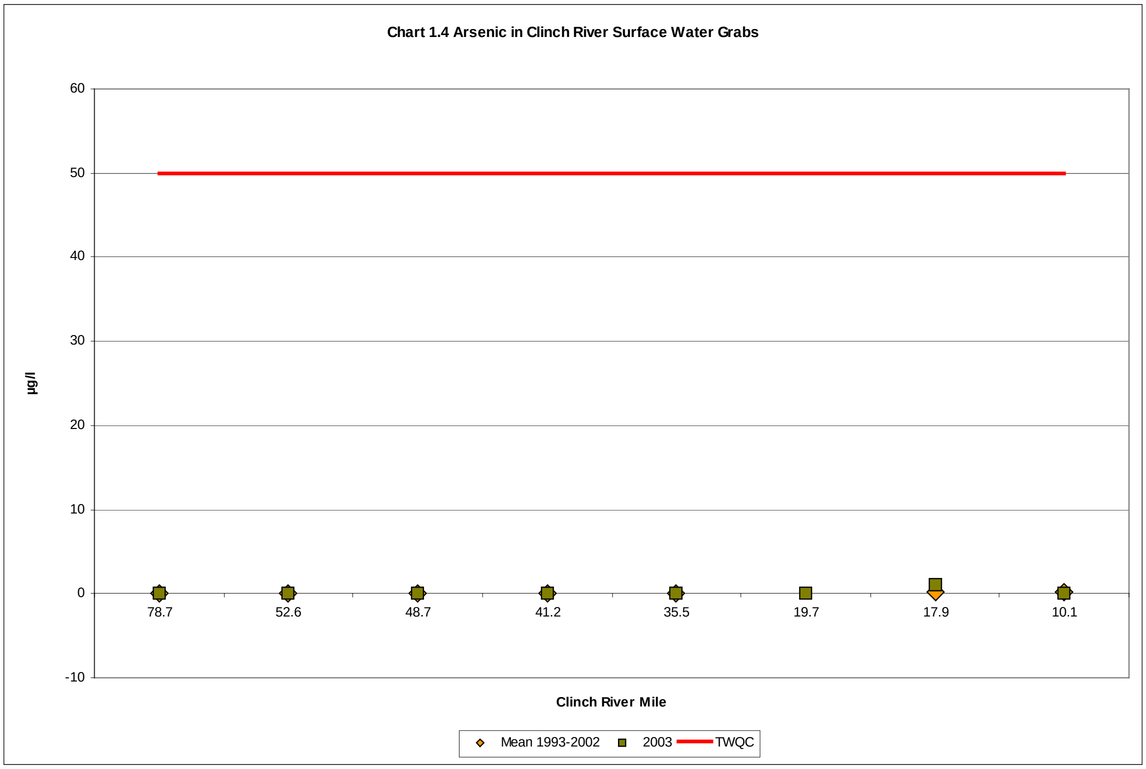


Chart 1.4 Arsenic in Clinch River Surface Water Grabs
µg/l
60
50
40
30
20
10
0
-10
78.7
52.6
48.7
41.2
35.5
19.7
17.9
10.1
Clinch River Mile
Mean 1993-2002
2003
TWQC

## Conclusion

The water quality of the Clinch River and the tributaries sampled is good. Lab results indicate that there is no threat to human health or wildlife.

**Table 1.1 Sample Locations:**

| Site | Location | Clinch River Mile | Map |
|---|---|---|---|
| 1 | Downstream of Norris Dam | 78.7 | Figure 1.5 |
| 2 | Clinch River Mile 52.6 | 52.6 | Figure 1.4 |
| 3 | Melton Hill Park | 35.5 | Figure 1.3 |
| 4 | Grubb Islands | 17.9 | Figure 1.2 |
| 5 | Brashear Island | 10.1 | Figure 1.1 |
| 6 | Bull Run Steam Plant | 48.7 | Figure 1.4 |
| 7 | Clinch River Mile 41.2 | 41.2 | Figure 1.3 |
| 8 | Scarboro Creek | 41.2 | Figure 1.3 |
| 9 | Kerr Hollow Branch | 41.2 | Figure 1.3 |
| 10 | McCoy Branch | 37.5 | Figure 1.3 |
| 11 | Western Branch | 37.5 | Figure 1.3 |
| 12 | East Fork of Walker Branch | 33.2 | Figure 1.3 |
| 13 | Bearden Creek | 31.8 | Figure 1.3 |
| 17 | Unnamed Stream | 20.0 | Figure 1.2 |
| 18 | Raccoon Creek | 19.5 | Figure 1.2 |
| 19 | Ish Creek | 19.1 | Figure 1.2 |
| 20 | Grassy Creek | 14.55 | Figure 1.2 |
| 21 | Unnamed Stream | 14.55 | Figure 1.2 |
| 22 | Unnamed Stream | 14.45 | Figure 1.2 |
| 23 | Ernie’s Creek | 51.1 | Figure 1.4 |
| 24 | White Creek | 102.4 | Figure 1.6 |
| 25 | Clear Creek | 77.7 | Figure 1.5 |
| 32 | Jones Island | 19.7 | Figure 1.2 |
| 33 | Poplar Creek | 12.0 | Figure 1.2 |
| 34 | Walker Branch | 33.2 | Figure 1.3 |
| 35 | Unnamed Stream | 18.7 | Figure 1.2 |

Sampling Sites

*Site 1 – Downstream of Norris Dam:* Samples are taken at Clinch River Mile (CRM) 78.7. The coordinates are approximately 36º 13' 11" N latitude and 84º 05' 20" W longitude. (See Figure 1.5).

*Site 2 - Anderson County Water Treatment Plant:* Samples are taken at CRM 52.6. (See Figure 1.4).

*Site 3 - Melton Hill Park:* Samples are taken at CRM 35.5. (See Figure 1.3).

*Site 4 - Grubb Islands:* Samples are taken at CRM 17.9. The coordinates are approximately 35º 53' 52" N latitude and 84º 22' 24" W longitude. (See Figure 1.2).

*Site 5 - Brashear Island:* Samples are taken at CRM 10.1. The coordinates are approximately 35º 55' 13" N latitude and 84º 26' 02" W longitude. (See Figure 1.1).

*Site 6 - Bull Run Steam Plant:* Samples are taken at CRM 48.7. The coordinates are approximately 36º 01' 28" N latitude and 84º 10' 02" W longitude. (See Figure 1.4).

*Site 7 – Oak Ridge City Water Treatment Plant: (*See Figure 1.3).

*Site 8 - Scarboro Creek:* Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 59" N latitude and 84º 13' 00" W longitude. (See Figure 1.3).

*Site 9 - Kerr Hollow Branch:* Samples are taken about 200 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 45" N latitude and 84º 13' 37" W longitude. (See Figure 1.3).

*Site 10 - McCoy Branch:* Samples are taken underneath the power lines just upstream from Melton Hill Lake. The coordinates are approximately 35º 57' 57" N latitude and 84º 14' 54" W longitude. (See Figure 1.3).

*Site 11 - Western Branch:* Samples are taken about 500 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 58' 00" N latitude and 84º 15' 05" W longitude. (See Figure 1.3).

*Site 12 - East Fork of Walker Branch:* Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 57' 22" N latitude and 84º 15' 58" W longitude. (See Figure 1.3).

*Site 13 - Bearden Creek:* Samples are taken about 300 feet upstream of Melton Hill Lake. The coordinates are approximately 35º 56' 05" N latitude and 84º 17' 01" W longitude. (See Figure 1.3).

*Site 14 – Unnamed Stream:* Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 25" N latitude and 84º 16' 39" W longitude. (See Figure 1.3).

*Site 15 – Unnamed Stream:* Samples are taken about 75 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 21" N latitude and 84º 17' 06" W longitude. (See Figure 1.3).

*Site 16 – Unnamed Stream:* Samples are taken about 100 feet upstream of the Clinch River. The coordinates are approximately 35º 53' 22" N latitude and 84º 18' 04" W longitude. (See Figure 1.2).

*Site 17 – Unnamed Stream:* Samples are taken about 2000 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 14" N latitude and 84º 20' 12" W longitude. (See Figure 1.2).

*Site 18 - Raccoon Creek:* Samples are taken about 1500 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 12" N latitude and 84º 21' 05" W longitude. (See Figure 1.2).

*Site 19 - Ish Creek:* Samples are taken about 1500 feet upstream of the Clinch River. The coordinates are approximately 35º 54' 11" N latitude and 84º 21' 33" W longitude. (See Figure 1.2).

*Site 20 - Grassy Creek:* Samples are taken about 200 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 55" W longitude. (See Figure 1.2).

*Site 21 – Unnamed Stream:* Samples are taken about 75 feet from the confluence with the Clinch River/Grassy Creek Embayment. The coordinates are approximately 35º 54' 36" N latitude and 84º 22' 57" W longitude. (See Figure 1.2).

*Site 22 – Unnamed Stream:* Samples are taken approximately 100 feet from the confluence with the Clinch River. The coordinates are approximately 35º 54' 29" N latitude and 84º 23' 25" W longitude. (See Figure 1.2).

*Site 23 – Ernie's Creek:* This stream is located behind Warehouse Road in Oak Ridge. Samples are taken a short distance upstream of the Clinch River embayment at Clinch River Mile 51.1. The approximate coordinates are 36º 02' 19" N latitude and 84º 12' 47" W longitude. (See Figure 1.4).

*Site 24 – White Creek:* This stream is located in the Chuck Swann Wildlife Management Area in Union County. Samples are taken about one mile upstream of Norris Lake/Clinch River. The approximate coordinates are 36º 20' 47" N latitude and 83º 53' 42" W longitude. (See Figure 1.6).

*Site 25 – Clear Creek:* This stream is located near Norris Dam near Clinch River Mile 77.7 Samples are taken near a water storage facility about one mile upstream of the river. The approximate coordinates are 36º 12' 49" N latitude and 84º 03' 33" W longitude.  This is a background site. (See Figure 1.5).

*Site 32 – Clinch River Mile 19.7 (below Jones Island):* The coordinates are approximately 35º 54' 03" N latitude and -84º 21' 02" W longitude. (See Figure 1.2).

*Site 33 – Poplar Creek Mile 0.5:* The coordinates are approximately 36º 01' 03" N latitude and -84º 14' 21" W longitude. (See Figure 1.1).

*Site 34 – Walker Branch:* The coordinates are approximately 35º 57' 10" N latitude and -84º 16' 25" W longitude. (See Figure 1.3).

*Site 35 – Unnamed Stream:* The coordinates are approximately 35º 54' 04" N latitude and -84º 21' 59" W longitude. (See Figure 1.2).

**Figure 1.1: Monitoring Sites**

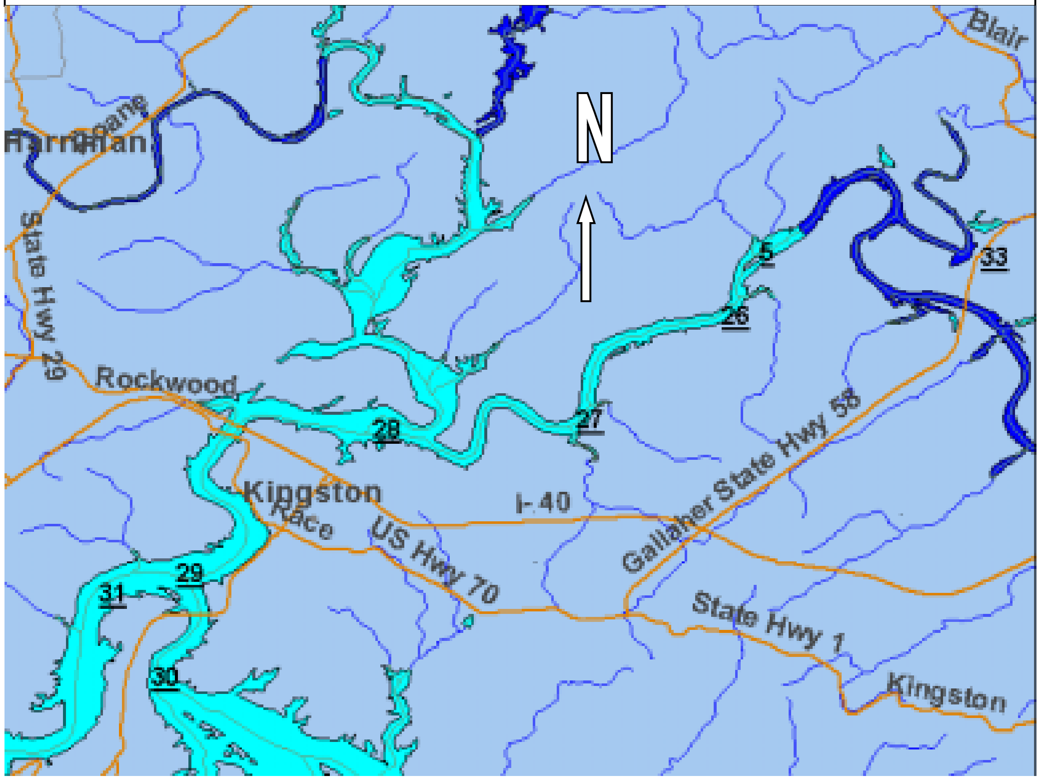



**Figure1.2: Monitoring Sites**

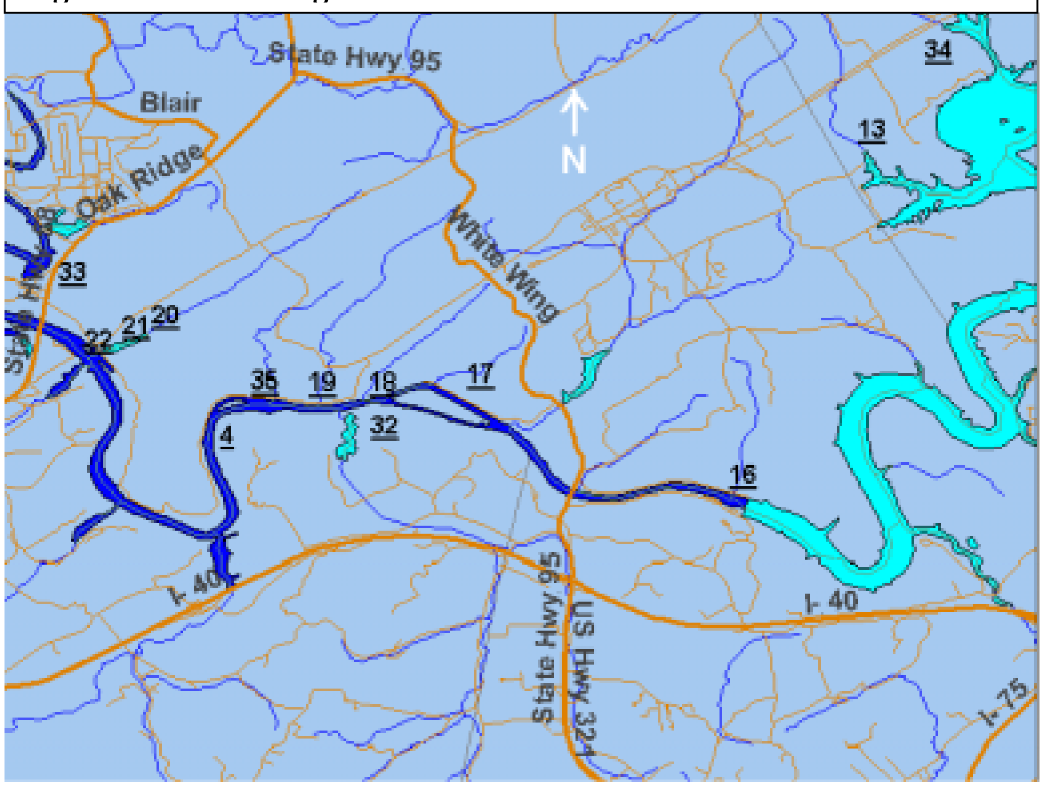


**Figure 1.3: Monitoring Sites**

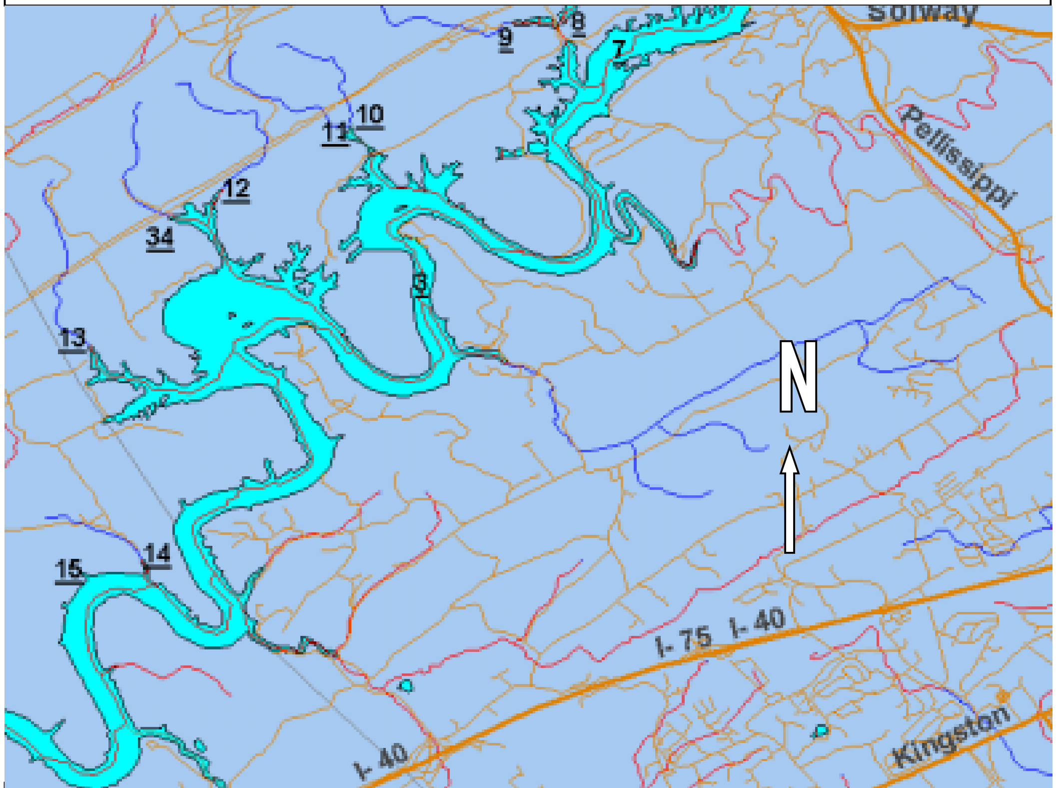



**Figure 1.4: Monitoring Sites**

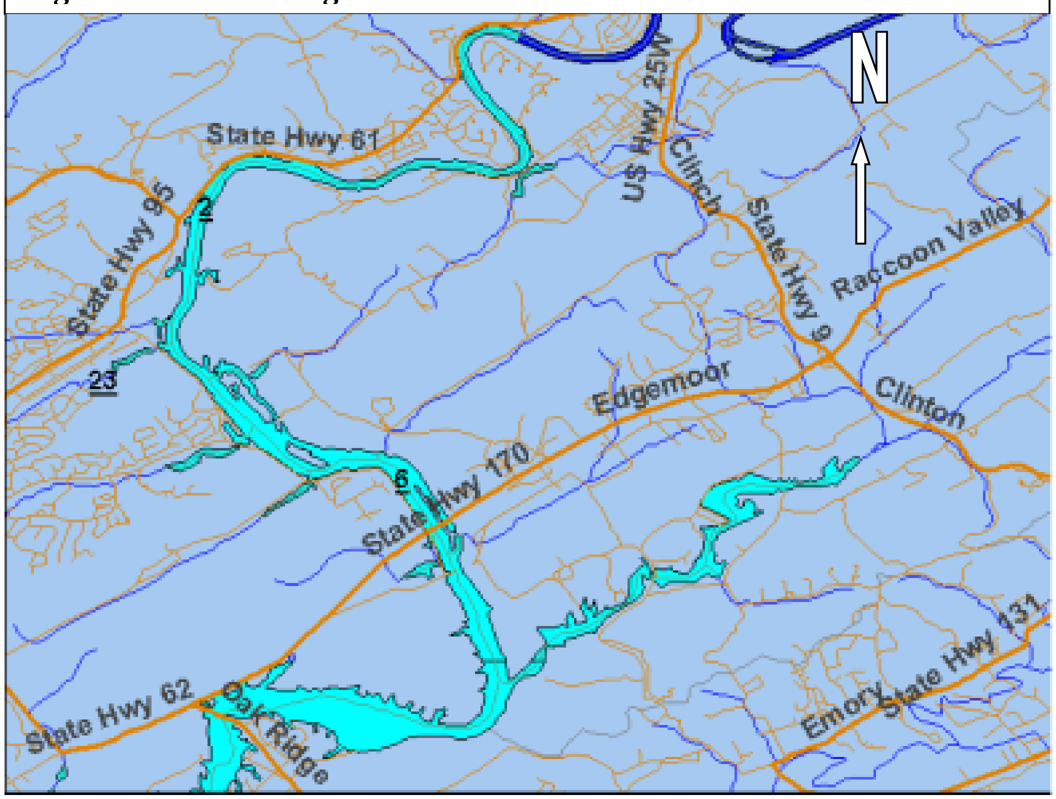


**Figure 1.5: Monitoring Sites**

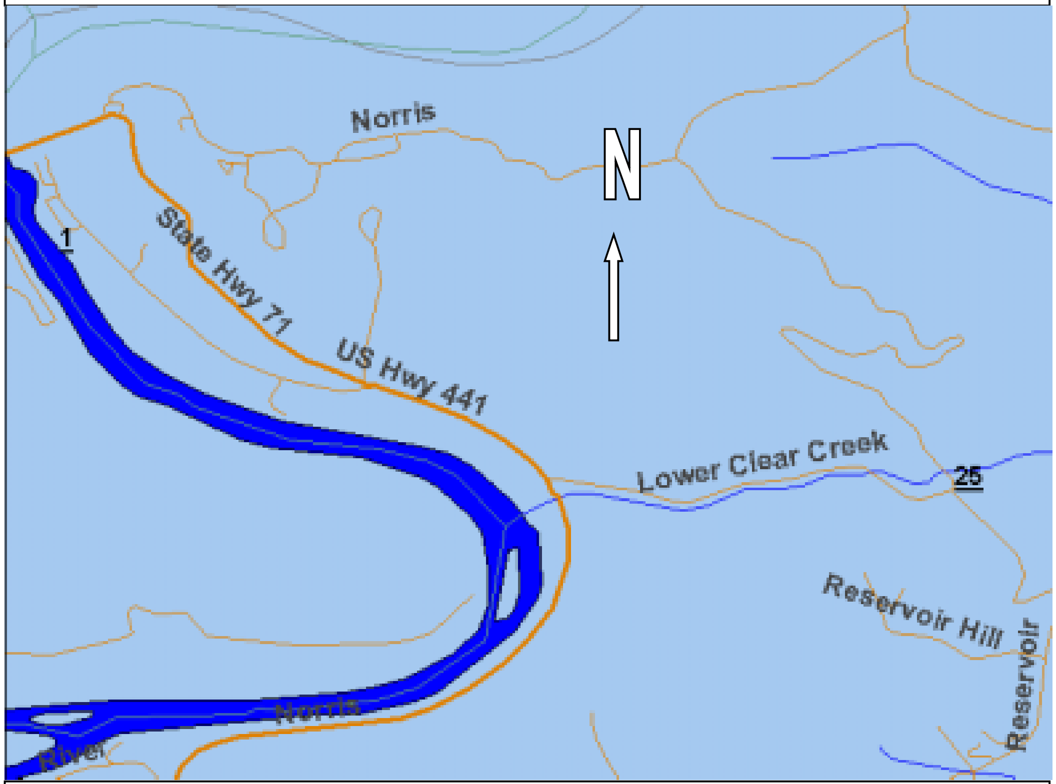
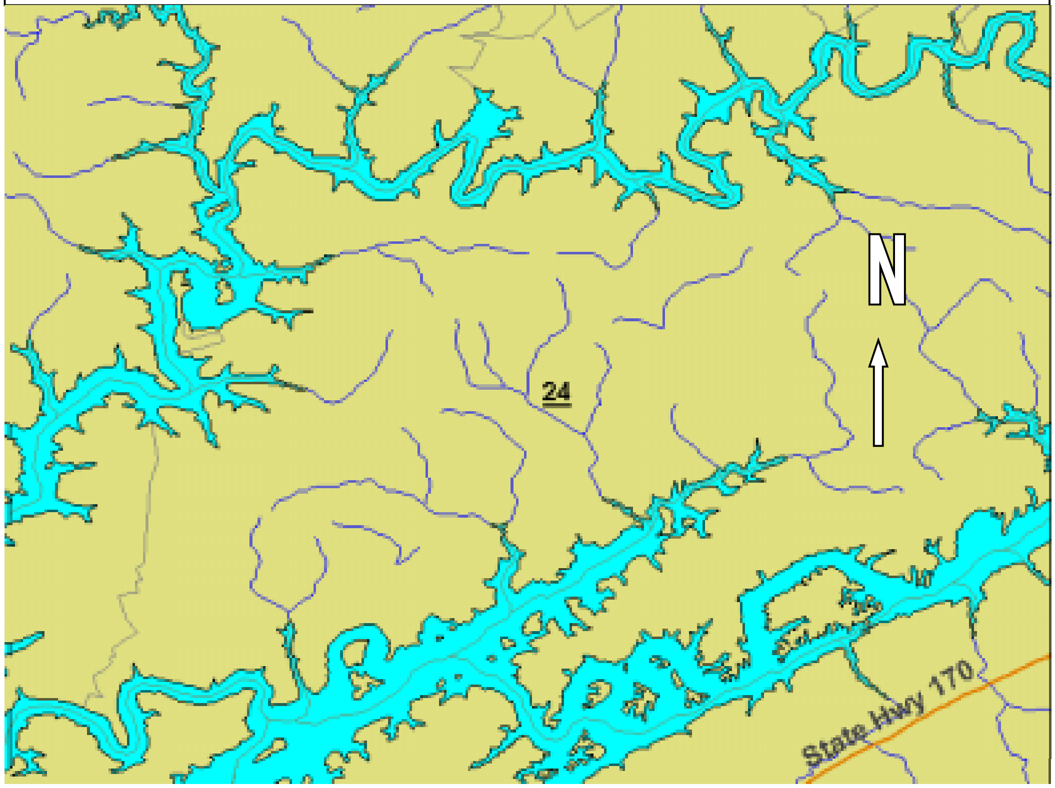



**Figure 1.6: Monitoring Sites**



**References**

Tennessee Department of Environment and Conservation. 1997. *State of Tennessee Water Quality Standards, Rules of the Department of Environment and Conservation, Bureau of Environment, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria, Chapter 1200-4-4 Use Classifications for Surface Waters*. Nashville, Tennessee.

Tennessee Department of Environment and Conservation, Department of Energy-Oversight. 1996. *Standard Operating Procedures.* Oak Ridge, Tennessee.

Tennessee Department of Health Laboratory Services. 1999. *Standard Operating Procedures.* Tennessee Department of Health Laboratory Services. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 1998. *The Status of Water Quality in Tennessee: Technical Report.* Tennessee Department of Environment and Conservation, Division of Water Pollution Control. Nashville, Tennessee.

Tennessee Department of Environment and Conservation. 2001. *Tennessee Oversight Agreement, Agreement between the U.S. Department of Energy and the State of Tennessee*. Oak Ridge, Tennessee.

U. S. Environmental Protection Agency. Enforcement and Investigations Branch. Region 4. 1997. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).* Athens, Georgia.

Yard, C. R. 2002. *Health, Safety, and Security Plan.* Tennessee Department of Environment and Conservation Department of Energy Oversight Division. Oak Ridge, Tennessee.